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NEW OR LITTLE KNOWN NORTH AMERICAN TREES

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IN the tenth volume of *The Silva of North America*, which was published on November 30, 1896, descriptions and figures of two species of Thrinax from southern Florida were included, and an allusion was made to the existence of two other Florida species known only from fragmentary specimens. Since the appearance of that volume I have made three journeys to the keys of southern Florida for the special purpose of studying the plants of this group, and at last I have obtained sufficient material to throw some further light on their characters and distribution.

In the original description of the genus Thrinax, founded by Swartz on a West Indian tree, the fruit is described as baccate, the size of a small pea and slightly fleshy, with a single seed, white in the interior with a red middle ("nucleus solitarius, nauco osseo fragili tectus, intus albus, medio ruber"). Martius, in 1824, in his *Palmarum Familia ejusque Genera*, practically adopted Swartz's characters for the genus, describing the albumen as "solidum, æquabile," but Endlicher, who next described Thrinax in the *Genera Plantarum*, speaks of it as "æquabile aut subruminatum," showing, probably, his acquaintance with some plant unlike the type of Swartz's genus. Martius in the *Historia Palmarum* also calls the fruit baccate, Swartz's red interior of the seed being explained by the infolding of the testa which leaves

a deep basal cavity in the horny albumen. Martius, however, now enlarged the genus to include the *Thrinax argentea* of Roemer & Schultes, with seed marked by numerous vertical grooves caused by the regular infolding of the testa into the lobed albumen ("nucleus vasis impressis a basi sursum decurventibus insculptus"). Bentham & Hooker, who next described the genus, speak of the seed as vertically sulcate ("sulcis sinuatis verticalibus exculptum") without referring to the fact that in the type of the genus and in some of the species referred to it by Martius the seed is simply penetrated by a basal cavity. Drude in his study of the genus divided it into three sections, Euthrinax for the species with sulcate seeds and ruminate albumen; Heminothrinax for the younger Hooker's monotypic genus of that name with setulose perianth lobes, sessile extrorse anthers, and seeds penetrated by deep basal cavities; and Porothrinax, a name proposed (without characters) by Wendland in Grisebach's *Catalogus Plantarum Cubensium* for *Thrinax pumilio*, the type of a group of species with nearly sessile flowers, ovate acute perianth lobes, triangular filaments, and uniform albumen penetrated by a deep basal cavity—that is, with seeds similar in structure to those of Swartz's type of Thrinax. Baillon followed Drude in his treatment of the genus, and in the tenth volume of *The Silva of North America* this arrangement was also adopted. An examination of fresh material shows, however, that the fruit of the Florida species with uniform albumen penetrated by a basal cavity is drupaceous and ivory-white, and that in those species in which the seed is vertically sulcate by the infolding of the testa into the ruminate albumen the fruit is baccate and black. Principally for this reason, and for some less important characters, I propose to group the Thrinax-like plants of Florida in two genera as follows:[1]

[1] In all the Thrinax-like plants of Florida the pericarp remains thin and crustaceous until the seed is fully developed, and then quickly thickening becomes succulent and very juicy, a character which is not often apparent in the herbarium, as the fruit is frequently collected before the pericarp begins to thicken. Even when it is gathered fully ripe the flesh becomes thin and leathery in drying and gives a very imperfect idea of the fresh fruit.

THRINAX Swartz.

THRINAX Swartz, Prodr. 57. 1788; Fl. Ind. Occ. 1:614. *pl. 13.*— Martius, Palm. Fam. Gen. 8; Hist. Nat. Palm. 3:255 (in part).— Endlicher, Gen. 357 (in part).— Drude, in Engler & Prantl Pflanzenfam. II. 3:34 (§ *Porothrinax*). — Sargent, Silva, 10:49 (§ *Porothrinax*).

Flowers solitary, minute, articulate on slender elongated or stout abbreviated disk-like pedicels in the axils of ovate acute deciduous bracts. Perianth cupular, truncate at the base, six-lobed, the lobes obscure or broadly ovate and acute, persistent under the fruit. Stamens six (or nine),[2] inserted on the base of the perianth; filaments subulate, thick and scarcely united at the base, or nearly triangular and joined below into a cup adnate to the perianth; anthers oblong, two-celled, opening longitudinally, inserted on the back below the middle, introrse, becoming reflexed and extrorse at maturity. Ovary superior, ovoid, one-celled, gradually narrowed into a stout columnar style crowned by a broadly funnelform flat or oblique stigma; ovule solitary, basilar, erect, hemi-anatropous; micropyle lateral. Fruit drupaceous, one-seeded, globose, marked at the apex with the remnants of the style and bearing at the base the slightly thickened perianth of the flower; sarcocarp thin, green, crustaceous, ultimately much thickened, ivory-white, juicy, bitter and easily separable from the thin putamen of two closely adherent coats, the outer crustaceous, pale tawny-brown and slightly tuberculate, the inner membranaceous, silvery-white and lustrous. Seed free, erect, nearly globose, slightly flattened at the two ends, depressed at the base; hilum subbasilar, oblong, pale, conspicuous; raphe short, unbranched, obscure; testa thin, pale or dark chestnut brown and lustrous; albumen uniform, more or less deeply penetrated by a broad basal cavity; embryo lateral.

Unarmed trees with simple elongated or rarely short stems marked below with the ring-like scars of fallen leaf-stalks and

[2] In Swartz's *Thrinax parviflora*, the type of the genus, and in all the Florida species, there are six stamens, but in *Thrinax excelsa* Grisebach, of Jamaica, the number is said to be nine, although this fact does not appear in the recent description of the species in *The Botanical Magazine* (115: *pl. 7088*).

clothed above with the long persistent vaginas, and long tough wiry roots covered with thick orange-brown loosely attached rind. Leaves alternate, induplicate in vernation, orbicular or truncate at the base, thick and firm, usually silvery white on the lower surface, more or less divided into two-parted obliquely folded lobes with thickened margins and midribs; rachis reduced to a narrow border with a thin usually undulate reflexed margin; ligule thick, concave, pointed, often lined while young with hoary tomentum; petioles stout, elongated, flattened, slightly rounded above and below, their margins thin and smooth, concave toward the base and gradually enlarged into vaginas of coarse netted fibers covered with thick hoary tomentum. Spadix paniculate, interfoliar, pedunculate, as long as or longer than the petioles; its primary branches short, alternate, compressed, incurved, furnished with numerous slender terete alternate flower-bearing branchlets in the axils of ovate acute scarious deciduous bracts; spathes numerous, tubular, thick and firm, coriaceous, two-cleft and more or less tomentose toward the apex.

To Thrinax, in addition to the three Florida species, should be referred *Thrinax parviflora* Sw., *Thrinax excelsa* Griseb., *Thrinax Morrisii* H. Wendl., *Thrinax multiflora* Mart., and *Thrinax pumilio* R. & S.

PEDICELLATAE. Flowers long-pedicellate; perianth obscurely lobed or nearly truncate; filaments subulate, hardly united at the base, much exserted; stigma oblique.

Thrinax Floridana, n. sp.

Thrinax parviflora Vasey, Rep. U. S. Dept. Agric. **1875**: 186 (*Cat. Forest Trees U. S.* (not Swartz) 1876.—Chapman, BOT. GAZETTE **3**: 12; Flora S. States, Suppl. [ed. 2] 651, [ed. 3] 462.—Sargent, Silva **10**: 51 (in part), *pl. 510* as to the leaf.

Flowers on slender pedicels nearly an eighth of an inch long, ivory-white, very fragrant with a pungent aromatic odor. Fruit from one quarter to three eighths of an inch in diameter, somewhat depressed above and below. Seed from an eighth to

nearly a quarter of an inch in diameter, dark chestnut-brown and lustrous, penetrated nearly to the apex by the broad basal cavity.

A tree with a slightly tapering stem from twenty to thirty feet in height and from four to six inches in diameter, covered with smooth pale blue-gray rind and generally clothed to the middle and occasionally to the ground with the persistent clasping bases of the leaf-stalks. Leaves nearly orbicular, or truncate at the base, rather longer than they are broad, yellow-green and lustrous on the upper surface, silvery-white on the lower surface, divided to below the middle into numerous lobes varying from an inch to an inch and a half in width near the middle of the leaf; ligule long-pointed, bright orange color, three quarters of an inch long and broad; petioles from four feet to four feet and a half in length, pale yellow-green, three quarters of an inch wide at the orange-colored more or less tomentose apex, much thickened and tomentose and from two inches to two inches and a half wide at the base. Spadix from three feet to three feet six inches in length, its primary branches from six to eight inches long, ivory-white when the flowers open like the slender secondary branches, but turning light yellow-green before the fruit ripens and orange-brown in drying. Flowers in June and sometimes also irregularly in October or November; fruit ripening six months later.

Dry coral ridges and sandy shores from Cape Romano to Cape Sable on the mainland and from Torch Key to Long Key. Discovered by Dr. A. W. Chapman on Cape Romano in the autumn of 1875, and on Cape Sable by Dr. A. P. Garber in October 1879. This is the *Thrinax excelsa* of Florida nurserymen but not of Grisebach. Closely related probably to *Thrinax parviflora* of Swartz, which appears to be widely distributed through the West Indies and to occur on the shore of Central America, but distinct from that species, as collected by Charles Wright in Cuba (*no. 2329*) and determined by H. Wendland, in its longer and stouter fruiting pedicels, smaller fruit and deeper seminal cavity, and pronounced unlike any of the species of

Thrinax in the Herbarium of the Royal Gardens at Kew, where, through the courtesy of the director, Mr. W. T. Thiselton Dyer, my Florida material has been compared.

Seeds of *Thrinax Floridana* were distributed from the Arnold Arboretum in December 1898, as *Thrinax species no. 2.*

SESSILIFLORÆ. Flowers short-pedicellate; perianth lobes broadly ovate, acute; filaments nearly triangular, united below into a cup adnate to the perianth; stigma flat.

Thrinax Keyensis, n. sp.— Flowers on low disk-like pedicels, ivory-white, faintly aromatic. Fruit from one sixteenth to nearly one quarter of an inch in diameter, with thin flesh. Seed three sixteenths of an inch in diameter, pale chestnut-brown, penetrated only to the middle by the basal cavity.

A tree with an ashy-gray stem often twenty-five feet in height and from ten to fourteen inches in diameter, raised on a base of thick matted roots two or three feet high and eighteen or twenty inches wide. Leaves nearly orbicular or truncate at the base but rather longer than broad, from three to four feet in length, divided for two thirds of their length into lobes which are often two and a half inches wide near the middle of the leaf, the lowest lobes parallel with the petiole or spreading from it at right angles, thick and firm, light yellow-green and very lustrous on the upper surface, with bright orange-colored midribs and much thickened orange-colored margins to the lobes, on the lower surface at first coated with hoary deciduous tomentum and at maturity pale blue-green and more or less covered with loosely attached silvery-white pubescence; ligule thick, pointed, an inch long and wide, lined at first with hoary tomentum; petioles stout, flattened above, obscurely ridged on the lower surface, tomentose while young, pale blue-green, from three to four feet long, an inch wide at the apex, and from three to four inches wide at the much thickened concave base, coated like the broad vaginas of coarse tough fibers with felt-like tomentum. Spadix six feet long, stout, spreading, gracefully incurved, its primary branches much compressed, from three to four inches in

length at the base of the panicle to an inch and a half in length at the apex, bright orange colored like the short secondary branches. Flowers opening in June and occasionally also irregularly in November; the fruit ripening six months later.

Thrinax Keyensis inhabits the north shore of the largest of the Marquesas group of islands about fifteen miles west of Key West, where it was first seen by me in November 1886, but without flowers or fruit, and where there are several large groves; it grows also on Crab Key, a small island to the westward of Torch Key, one of the Bahia Honda group. It is this plant which I referred to EUTHRINAX (Garden and Forest **9**: 162; Silva **10**: 50), with the mistaken idea that the large black fruit which I had gathered on the Marquesas in 1886 had been produced by this tree. Seeds of *Thrinax Keyensis* were distributed from the Arnold Arboretum in December 1898 as *Thrinax no. 3*.

THRINAX MICROCARPA Sargent, Garden and Forest **9**: 162. 1896; Silva **10**: 53. *pl. 511*.

This tree, which is the commonest and most generally distributed species on the south Florida keys, is correctly figured in the tenth volume of *The Silva*, except the fruit, which, until recently, I supposed to have an orange-brown crustaceous pericarp. It differs from *Thrinax Keyensis* in its taller and more slender trunk without a basal enlargement, in its shorter spadix and smaller fruit with darker colored seeds, and in its smaller and thinner leaves. The structure of the flower and fruit is identical. This is the *Thrinax argentea* of Curtiss's distribution (*no. 2679*), but not of Loddiges, which belongs to another genus.

COCCOTHRINAX, n. gen. CORYPHEÆ.

Thrinax Endlicher, Gen. 253. 1836 (in part). Martius, Nat. Hist. Palm. **3**: 254 (in part). Bentham & Hooker, Gen. **3**: 930. Drude in Engler & Prantl Pflanzenfam. II. **3**: 34 (§ EUTHRINAX). Baillon, Hist. Pl. **13**: 317 (in part). Sargent, Silva **10**: 49 (§ EUTHRINAX.)

Flowers perfect, solitary, minute, articulate on slender pedicels in the axils of ovate acute caducous bracts. Perianth cupu-

lar, truncate at the base, obscurely six-lobed, deciduous. Stamens nine, inserted on the base of the perianth, exserted; filaments subulate, barely united at the base; anthers oblong, attached on the back near the middle, introrse, two-celled, the cells opening longitudinally. Ovary superior, ovoid, one-celled, narrowed above into a slender columnar style crowned by the funnelform oblique stigma; ovule solitary, basilar, anatropous; micropyle subbasilar. Fruit baccate, subglobose, one-seeded, crowned with the remnants of the style, raised on the thickened torus of the flower; exocarp at first thin, of two closely united coats, the outer crustaceous, bright green, the inner membranaceous, silvery-white; in ripening becoming thick, sweet, juicy, homogeneous, black and lustrous, easily separable from the seed. Seed free, erect, depressed-globose; testa thick and hard, vertically sulcate with numerous narrow grooves running irregularly from the base of the seed toward its apex, deeply infolded into the ruminate albumen; hilum subbasilar, minute, obscure; raphe hidden in the folds of the testa; embryo lateral.

Trees with slender stems marked below by the ring-like scars of fallen leaf-stalks and clothed above with the long-persistent petiole-sheaths, or rarely stemless. Leaves terminal, induplicate in vernation, alternate, orbicular or truncate at the base, pale or silvery-white on the lower surface, thin and brittle, more or less deeply divided into narrow acute two-parted obliquely folded lobes; rachis short; ligule free, thin, erect, concave, rounded or long, pointed at the apex; petioles compressed, slightly rounded and ridged on the two surfaces, thin and smooth on the margins, gradually enlarged below into elongated vaginas of coarse fibers forming an open conspicuous net work generally clothed while young with thick hoary tomentum. Spadix interfoliar, paniculate, shorter than the petioles; its short primary branches incurved, furnished with numerous short flower-bearing secondary branchlets from the axils of scarious acute bracts; spathes numerous, papyraceous, two-cleft at the apex.

The generic name is in allusion to the berry-like fruit.

The following extra-Florida species previously referred to

Thrinax belong in Coccothrinax. *Thrinax argentea* R. & S.; *Thrinax radiata* R. & S. (*Thrinax gracilis*, *elegans* and *aurita* of gardens). Wright's *no. 3966* from Cuba labeled *Thrinax acuminata* Griseb. & Wendl., apparently an unpublished name, also belongs to this genus.

Coccothrinax jucunda, n. sp.

Thrinax parviflora Sargent, Forest Trees N. Am., Tenth Census U. S. 9:217. 1884 (not Swartz); Silva 10:51, in part *pl. 510* (excl. figure of leaf).

Thrinax argentea Chapman, Flora S. St. [ed. 3]462. 1897 (not Roemer & Schultes).

Flowers raised on rigid spreading pedicels an eighth of an inch long; perianth white; anthers light yellow; ovary orange color; stigma pale rose color. Fruit from one half to three quarters of an inch in diameter, bright green when fully grown, later becoming succulent, bright violet color, very lustrous and ultimately nearly black, the flesh sweet and edible. Seed light tawny-brown, from an eighth to a quarter of an inch in diameter. Flowers in June and also irregularly in November; fruit ripening six months later.

A tree with a stem slightly enlarged from the ground upward, from fifteen to twenty-five feet in height and from four to six inches in diameter, covered with pale blue-gray rind. Leaves nearly orbicular but rather longer than broad, thin and brittle, from eighteen to twenty-four inches in diameter, divided to below the middle or toward the base of the leaf nearly to the ligule into narrow lobes, an inch across in their widest part, with much thickened bright orange-colored midribs and margins, pale yellow-green and very lustrous on the upper surface, bright silvery-white on the lower surface: rachis thin, undulate, obtusely short-pointed, dark orange colored; ligule thin, concave, crescent shaped, often oblique, slightly undulate, occasionally obtusely short-pointed, three quarters of an inch wide, one third of an inch deep, light or dark orange color; petioles slender, flexible, soon becoming pendent, rounded on the upper side, obscurely ribbed on the lower side, with low rounded ribs, from two and a

half to three feet long, pale yellow-green, an inch and a half wide at the base, coated at first like the young leaves with silvery-white deciduous tomentum toward the orange colored apex. Spadix from eighteen to twenty-four inches in length with a flattened peduncle, slender, much flattened, primary branches from eight to ten inches long and light orange-colored like the slender terete secondary branches; spathes thin, fibrous, brittle, pale reddish-brown and coated toward the ends with pale pubescence.

Dry coral ridges from the shores of Bay Biscayne, where it is rare, along many of the southern keys to the Marquesas group, west of Key West. Discovered by A. H. Curtiss in 1880. Very similar to *Thrinax argentea* R. & S., the seeds differing, however, from those of that species as named in the herbarium of the Royal Gardens, Kew, in their brown, not mahogany-red, color and larger size.

Coccothrinax Garberi, nom. nov.

Thrinax Garberi Chapman, Bot. Gazette 3:12. 1878; Flora S. States Suppl. [ed. 2] 651. Sargent, Silva 10:50.

Thrinax argentea var. *Garberi* Chapman, Flora S. States [ed. 3] 462. 1897.

A stemless plant similar to the last in the structure of its flowers and fruit and in the texture and color of the leaves, but smaller in all its parts, the leaves being only about ten or twelve inches in diameter. Found only on dry coral ridges near the shores of Bay Biscayne, and possibly only a depauperate form of the last.

Serenoa arborescens, n. sp.— Flowers minute, one twentieth of an inch long or less, perfect, sessile, in from one to three-flowered clusters in the axils of ovate acute chestnut-brown bracts, bibracteolate. Calyx truncate at the base, three-lobed, the lobes oblong, rounded and more or less laciniate on the margins, light chestnut-brown, thickened and persistent under the fruit. Corolla yellow-green, three-parted to the base, the divisions valvate in æstivation, oblong-ovate, thick, concave,

acute and much thickened at the apex, grooved on the inner surface with two or three deep depressions, deciduous. Stamens six, included; filaments nearly triangular, united below and adnate to the short tube of the corolla; anthers short-oblong, attached on the back below the middle, introrse, two-celled, the cells opening laterally. Ovary oblong-obovate, of three carpels free below, united above into a slender elongated style; stigma minute, terminal on the fruit; ovule solitary, erect from the bottom of the cell, anatropous. Fruit drupaceous, one-seeded, globose, one third of an inch in diameter, black and lustrous, usually bearing at the base the minute abortive carpels; exocarp thin and fleshy; mesocarp thin, fibrous, orange colored, strong-smelling, closely investing the pale brown crustaceous putamen. Seed free, subglobose, somewhat flattened below; testa hard, chestnut-brown and lustrous, lighter-colored on the ventral side with a large pale circular mark; hilum basal; raphe ventral, oblong, acute, unbranched; micropyle joined to the testa by a pale band; albumen homogenous; embryo lateral.

A tree thirty or forty feet in height with one or several stems three or four inches in diameter, clothed above for many years with the vaginas of the leaf stalks and covered below with smooth pale gray bark, and erect or often more or less inclining and occasionally semiprostrate. The leaves are terminal, semi-orbicular, truncate at the base, thin and firm, bright yellow-green on the upper surface, blue-green on the lower surface, two feet wide and long, divided nearly to the base into narrow linear-lanceolate lobes, their midribs and margins only slightly thickened and pale yellow; rachis acute, its narrow border free, thin and membranaceous; ligule thin, concave, short-pointed, furnished with a deciduous membranaceous red-brown border a quarter of an inch wide; petioles slender, flat on the upper surface, convex and stoutly ribbed on the lower surface, from eighteen to twenty-four inches long, one third of an inch wide at the apex, an inch wide at the base, armed with stout flattened orange-colored teeth; vaginas thin and firm, bright mahogany-red, very lustrous, closely infolding the stem, their fibers thin and brittle. The

spadix is interfoliar, from three to four feet long, its stem slender and flattened; branches slender, elongated, paniculate, gracefully drooping, coated with hoary tomentum, the ultimate divisions terete; bracts ovate, acute, chestnut-brown; spathes six or eight, sheathing the peduncle, thick and firm, deeply two-cleft at the apex furnished with a narrow membranaceous red-brown border.

Margins of swamps adjacent to the Chockoloskee river in southwestern Florida.

This second species of Serenoa differs from the type of the genus, the well-known saw palmetto of the southern states, in its arborescent habit, more elongated spadix, much smaller flowers, and smaller globose fruit and seeds, and is certainly a most interesting addition to the trees of the United States. The existence of an undescribed arborescent palm on the Chockoloskee river was known to me as long ago as 1887, when it was discovered without flowers and fruit in the Royal Palm Hummock, not far from the town of Everglade, by the late P. W. Reasoner, of Oneco, Florida; but it was not until the past season that I obtained the flowers and fruit from Mr. R. G. Corbitt, of Immockalee, Florida, who has found this palm growing abundantly in the swamps about thirty miles southeast of Lake Trafford, near the head of the Chockoloskee. In December 1898, seeds of *Serenoa arborescens* were distributed from the Arnold Arboretum as "New palm from the Florida everglades."

Ulmus (MICROPTELEA) **serotina,** n. sp.—Arborescent. Leaves oblong to oblong-obovate, acuminate, variously oblique at the base, coarsely and doubly crenulate-serrate, membranaceous, glabrous and lustrous above, puberulous below on the prominent midribs and veins. Flowers perfect, autumnal, racemose, from buds in the axils of leaves of the year, long-pedicellate. Calyx six-parted to the base, its divisions oblong-obovate, rounded at the apex. Ovary sessile, narrowed below, hirsute. Samaras stipitate, oblong-elliptical, deeply two-parted at the apex, ciliate on the margins. Seeds obovate; raphe conspicuous. Young leaves, stipules and bracts unknown.

A tree with a trunk forty or fifty feet in height and from two to three feet in diameter covered with close pale gray bark, comparatively small spreading or pendulous branches, slender pendulous branchlets, light reddish-brown, lustrous and marked occasionally with white lenticels, growing darker during their second season, ultimately dark gray-brown and often furnished in their second or third year with two or three thick corky wings. The winter-buds are ovate, acute, a quarter of an inch in length and covered with numerous oblong-obovate dark chestnut-brown scales. The leaves are thin and firm in texture, yellow-green and lustrous on the upper surface, rather paler on the lower surface, from two to three inches in length, with prominent midribs and about twenty pairs of primary veins running to the points of the principal teeth and often forked near the margin of the leaf, obscure reticulate veinlets, and stout petioles a quarter of an inch in length; in the autumn they turn orange-yellow before falling. The flowers are reddish-brown with yellow anthers, and are borne on slender conspicuously jointed pedicels often an eighth of an inch long in many-flowered racemes from an inch to an inch and a half in length. The fruit, which ripens early in November, is about half an inch long and is fringed on the margins with long silvery-white hairs.

Banks of the French Broad river near Dandridge, Tennessee; limestone bluffs of the Cumberland river, near Nashville, Tennessee; limestone ridges near Huntsville, Alabama, and Rome, Georgia; occasionally planted as a shade tree in the streets of Huntsville and Rome, and when cultivated in good soil and with abundant space distinguished by its broad handsome head of pendulous branches.

Ulmus serotina was collected by Rugel on the French Broad river in October 1842[3]; it was found near Nashville, by Dr. A. Gattinger, as early, at least, as 1879, and, although he noticed its autumnal flowers, it was referred by him to *Ulmus racemosa*. It has been distributed without flowers or fruit as *Ulmus racemosa*

[3] One of Rugel's specimens, with a few fragmentary flowers, is preserved in the herbarium of Columbia University.

from the Biltmore Herbarium (*no. 3634 b*) from collections made at Nashville in 1897; and on the 9th of October, 1898, a single large tree in fruit was seen by Mr. John Muir, Mr. William M. Canby, and myself close to the high road which leads eastward from Huntsville across the ridge known as Monte Sano. Subsequently it was found to be abundant on the hills near Huntsville and on those in the neighborhood of Rome by Mr. C. L. Boynton, of the Biltmore Herbarium. It is the *Ulmus racemosa* of Chapman's *Flora* (ed. 2, Supplement, 649; ed. 3, 444) so far as relates to the river banks of Tennessee, and the *Ulmus racemosa* of Sargent's *Silva* (**7**:48) so far as relates to middle Tennessee.

Ulmus serotina is an interesting addition to the small group of autumn-flowering elms in which the calyx is divided to below the middle (MICROPTELEA of Spach), and to which belong *Ulmus crassifolia* Nutt. of southern Arkansas and Texas, and *Ulmus parvifolia* Jacq. of northern and central China. From these it differs in its racemose flowers, more deeply divided calyx with obovate lobes, and in its much larger and acuminate leaves. The Himalayan *Ulmus lancifolia* Roxb. (*Ulmus Hookeriana* Planchon), also with a deeply divided calyx, is placed by Planchon (De Candolle, Prodr. **17**: 162) in MICROPTELEA, but the flowers, which are borne in short racemes, appear in spring from the axils of leaves of a previous year.

ARNOLD ARBORETUM.

THE ECOLOGICAL RELATIONS OF THE VEGETATION ON THE SAND DUNES OF LAKE MICHIGAN.

PART I.—GEOGRAPHICAL RELATIONS OF THE DUNE FLORAS.

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY. XIII.

HENRY CHANDLER COWLES.

(WITH FIGURES 1–26)

I. Introduction.

THE province of ecology is to consider the mutual relations between plants and their environment. Such a study is to structural botany what dynamical geology is to structural geology. Just as modern geologists interpret the structure of the rocks by seeking to find how and under what conditions similar rocks are formed today, so ecologists seek to study those plant structures which are changing at the present time, and thus to throw light on the origin of plant structures themselves.

Again, ecology is comparable to physiography. The surface of the earth is composed of a myriad of topographic forms, not at all distinct, but passing into one another by a series of almost perfect gradations; the physiographer studies landscapes in their making, and writes on the origin and relationships of topographic forms. The ecologist employs the methods of physiography, regarding the flora of a pond or swamp or hillside not as a changeless landscape feature, but rather as a panorama, never twice alike. The ecologist, then, must study the order of succession of the plant societies in the development of a region, and he must endeavor to discover the laws which govern the panoramic changes. Ecology, therefore, is a study in dynamics. For its most ready application, plants should be found whose tissues and organs are actually changing at the present time in

response to varying conditions. Plant formations should be found which are rapidly passing into other types by reason of a changing environment.

These requirements are met *par excellence* in a region of sand dunes. Perhaps no topographic form is more unstable than a dune. Because of this instability plant societies, plant organs, and plant tissues are obliged to adapt themselves to a new mode of life within years rather than centuries, the penalty for lack of adaptation being certain death. The sand dunes furnish a favorable region for the pursuit of ecological investigations because of the comparative absence of the perplexing problems arising from previous vegetation. Any plant society is the joint product of present and past environmental conditions, and perhaps the latter are much more potent than most ecologists have thought. As will be shown in another place, even the sand dune floras are often highly modified by preexisting conditions, but on the whole the physical forces of the present shape the floras as we find them. The advancing dune buries the old plant societies of a region, and with their death there pass away the influences which contributed so largely to their making. In place of the rich soil which had been accumulating by centuries of plant and animal decay, and in place of the complex reciprocal relations between the plants, as worked out by a struggle of centuries, the advance of a dune makes all things new. By burying the past, the dune offers to plant life a world for conquest, subject almost entirely to existing physical conditions. The primary motive, then, which prompted this present study was the feeling that nowhere else could many of the living problems of ecology be solved more clearly; that nowhere else could ecological principles be subjected to a more rigid test.

This particular investigation was also prompted by the fact that the previous ecological studies of sand-dune floras have been carried on chiefly in European countries, and almost exclusively along marine coasts. There has been considerable difference of opinion as to the influence of salty soils and atmospheres upon the vegetation. It would seem that a comparison of dunes

along an inland fresh water lake with those along the sea should yield instructive results.

An ecological study of this character has a natural twofold division. In the first place the plant formations are to be investigated. The species characteristic of each formation must be discovered, together with the facts and laws of their distribution. The progressive changes that take place and the factors in the environment which cause these changes must be discussed. This phase of the subject is largely geographic, and will be the special feature of the present paper. In another paper it is the author's purpose to discuss the adaptations of the plants to their dune environment, paying especial attention to those species which show a large degree of plasticity, and which are found growing under widely divergent conditions. This second phase again has a natural twofold division, one part treating of gross adaptations such as are shown in plant organs and plant bodies, the other dealing with the anatomical structures of the plant tissues.

The material for the present paper has been gathered chiefly from the study of the dunes in northwestern Indiana in the vicinity of Chicago. These studies were carried on in the seasons of 1896, 1897, and 1898, frequent visits being made to various points at all seasons of the year. A portion of the summer seasons of 1897 and 1898 was spent in a more rapid reconnoissance along the entire eastern shore of Lake Michigan, including the group of islands toward the north end of the lake.

The work resulting in this paper has been carried on in connection with the Hull Botanical Laboratory of the University of Chicago, and the author gratefully acknowledges the kindly interest and cooperation shown by his associates among the faculty and students of the botanical department, especially Head Professor John M. Coulter, through whose influence the author was directed along lines of ecological research. The author further desires to express his great indebtedness to Dr. Eugen Warming, professor of botany at Copenhagen; his textbook on ecology and his treatises on the sand-dune floras of

Denmark have helped greatly to make clear the true content of ecology, and they have been a constant incentive to more careful and thorough work. Most of the photographs were taken especially for this paper by Mr. E. W. Martyn, a Chicago photographer. Some of the views were taken by Messrs. S. M. Coulter and H. F. Roberts, students in the Hull Botanical Laboratory. The map was prepared by Mr. S. M. Coulter.

II. General features of the coast of Lake Michigan.

Along the eastern shore of Lake Michigan there are hills of wind-blown sand almost continuously fringing the border of the lake. This line of sand hills also continues around the southern end of the lake and along the western shore as far as Chicago. These sand hills or sand dunes form striking topographic features in the landscape, and in this respect present a strong contrast to the level prairies or fields beyond.

Geologically speaking, the sand dunes belong to the most recent formations, as they are entirely post-glacial. In most cases the origin of the existing topographic forms is to be referred to the most recent phases of post-glacial history, and in many instances the topographic forms are either being made or unmade at the present time. As a rule the dunes are directly superposed upon the beach. On the northeastern shores of the lake, however, the dunes are commonly superposed upon bluffs of clay or gravel, sometimes 120 meters above the present beach.

In the lake region there is a decided prevalence of westerly winds, chiefly from the southwest or northwest. As a consequence, the dunes are found along the entire eastern and southern shores of the lake, whereas the dunes on the western shore, due to easterly winds are merely small hillocks of sand. Such small dunes have been seen at Waukegan, Ill., and on North Manitou and Beaver islands. The dunes toward the southern portion of the lake were created and fashioned, as a matter of necessity, almost entirely by the northwest winds. In order to secure any extensive formation of sand dunes, it is necessary for the wind to gather force by sweeping over the lake and to strike the coast

FIG. 1.—MAP OF THE SHORE OF LAKE MICHIGAN. SCALE, 1:2,850,000.

almost at right angles to the shore line. It will thus be seen that the most favorable theoretical locality for dunes in a region of northwest winds is on the southeast shore of a body of water in that region. As a matter of fact, the dune region increases in area and the dunes themselves increase in height and complexity as one passes from Chicago around the south end of Lake Michigan. The culmination of the dune formations actually occurs between Dune Park and Michigan City, and an examination of the accompanying map (*fig.* 1) will show that these localities have a shore line running nearly southwest to northeast. The contour of the dunes themselves also shows that they were shaped by northwest winds, as does the path formed by the sweeping of the wind.

The Dune Park region furnishes the most extensive area of present dune activity to be found along the southern coast of Lake Michigan, although the altitudes of individual dunes are much greater at many points in Michigan. Elsewhere the active dunes are usually confined to a very narrow belt fringing the shore, but at Dune Park the dunes are active from one to two kilometers inland, the front of the advancing dunes varying from 6 to 30 meters in height. The dune complex or area of dune activity at Dune Park covers perhaps 1000 hectares. The established dunes here as elsewhere cover a far greater area than do the active dunes, reaching inland three to eight kilometers. Between Chicago and Dune Park there is a most interesting series of parallel ridges, alternating with depressions, which often reach below the water level throughout the entire year. The origin of these ridges is scarcely within the province of this paper; their extreme regularity of contour, in addition to their persistent parallelism, seems hardly consonant with a dune origin. Because of the low altitude of these ridges and their protection from shore conditions, their flora is not typically xerophytic. Whatever the origin of these ridges, they represent a phase in the lake's history when its waters were much farther inland than at present. The active dunes at Dune Park are scarcely ever more than 30 meters in altitude, but there are

several established dunes which are more than 36 meters above the lake. The coast charts issued by the Corps of Engineers of the United States War Department figure a dune near Porter, Ind., which reaches an altitude of 57 meters above the lake. Of course, altitudes of individual dunes are subject to much change, although in the case of established dunes the figures need but slight revision. The highest series of dunes is along the Michigan shore between Michigan City and St. Joseph. A large number of dunes reach an altitude of more than 60 meters; several are over 90 meters high; and one is figured on the coast chart which has an altitude of 117 meters above the level of the lake. An inspection of the map will show that these dunes must have been shaped primarily by northwest winds.

The Michigan shore between St. Joseph and Frankfort, a distance of more than 250 kilometers, is fringed almost continuously with a narrow belt of dunes. Perhaps at no place within this region are there such extensive dunes in activity at the present time as at Dune Park, nor do the established dunes reach inland as a rule for more than a kilometer. At Dune Park there is a gradation in the altitude of the dunes as one goes inland, until the low sand ridges pass all but insensibly into the prairies beyond. Along the Michigan shore, however, there is a narrow fringe of dunes close to the lake, commonly much higher than at Dune Park, and the transition between these dunes and the normal inland country is rapidly passed and plainly marked.

A very striking feature along the Michigan shore is the tendency of rivers to form small lakes near their mouths. These lakes determine the presence of cities, since they furnish the best of harbors. An inspection of the map (*fig. 1*) shows the presence of such natural harbors at the mouths of rivers at Holland (Ottawa Beach), Grand Haven, Muskegon, Whitehall, Pentwater, Ludington, and Manistee. A large amount of the silt brought down by the rivers is deposited at the mouth, where the river currents are slackened by their opening out into the lake and by wave action. The waves pile up this sand along the beach and the winds pick it up and form extensive dunes at the

river's mouth. All along the Michigan coast the most extensive areas of active dunes are likely to be at the mouths of the rivers, so that dune formation is thus seen to be regulated by the supply of sand as well as by the relation of the coast line to the direction of the prevailing winds. Since the general direction of the Michigan coast line is north and south, and the prevailing winds southwest and northwest, dune formation tends to close up the mouths of the rivers on both sides. The result of this conflict between the river and air currents is seen in the formation of lakes whose entrance into Lake Michigan is constricted into a narrow passageway. The tendency of the wind to close these passageways is so great that navigation is often difficult, and the necessity for constant dredging and erection of windbreaks is obvious.

The dunes at the mouths of rivers furnish a rough measure for determining the relative influence of northwest and southwest winds in dune formation, since those on the south side are largely shaped by southwest winds and those on the north side by northwest winds, although each wind modifies the action of the other. At Saugatuck the southwest winds appear to dominate, since the dune south of the river is 78 meters high, while to the north the heights are inconspicuous. The course of the Kalamazoo river has been deflected to the northward at this point, although it is interesting to observe that the mouth is now being deflected to the southward, the river filling in on the northwest bank and eroding on the southeast. At Ottawa Beach the dunes are about equal on both sides, and less than 60 meters in height. At Grand Haven there is an immense active dune on the north side of the river, 66 meters high, and with an advancing lee slope 45 meters in height. This dune is deflecting the river to the southward, and attempts to stop its progress are not particularly successful. The dunes at Muskegon are largest on the south side of the river. At Pentwater, Ludington, and Manistee the dunes average about 45 meters in height. The fringe of dunes is interrupted at several points by clay bluffs, but this latter formation is far more extensive farther northward.

Active dune formation is conspicuous on projecting points of land as well as at the mouths of rivers; for example, active dunes are to be found on Little Point Sable, south of Pentwater, and Big Point Sable, north of Ludington. At many points along the coast the winds are breaking through the fringe of established dunes, so that the older dunes may be said to have started into activity again or to have become rejuvenated. In summation concerning the area between St. Joseph and Frankfort, it may be said that the influence of northwest and southwest winds in dune formation is nearly equal. Indeed, the two winds commonly work together to produce a composite result, so that the winds sweep and the dunes advance, as a rule, from west to east.

In northern Michigan, between Frankfort and Glen Haven, and also on North Manitou island, most of the dunes are perched high up on bluffs of clay or gravel. The bluffs are steep and approach the water's edge, varying in height from nothing up to more than 120 meters. Dunes are to be found upon the tops of the very highest of these bluffs in the district south of Glen Haven. These perched dunes are almost wholly established, and it seems as if their formation took place years ago when the lake was perhaps at a higher level. The most remarkable dune formation along the entire coast of Lake Michigan is to be found on Sleeping Bear point, just south of Glen Haven. The point stretches out into the lake, and is constantly growing to the northward and eastward by reason of the joint action of waves and winds. The point proper is geologically quite young, and, apart from the present beach and stationary beach dunes, is covered by an immense and active dune complex. At many points the wind has scooped out great hollows in the complex, exposing the gravel of a former beach. The advance of the dunes in this area is chiefly eastward, the exposed fossil beaches being chiefly toward the west. Two or three kilometers southward from the point, the region of low active dunes passes somewhat suddenly into an immense flat-topped hill, rising abruptly from the lake like a mesa or terrace. The height of the dunes on the point is seldom greater than 30 to 45 meters, while this peculiar

gravel terrace, or mesa, has an average height of 120 meters above the lake level, and an area of more than 2000 hectares, since it extends inland for about two kilometers, and along the coast for, perhaps, 15 kilometers. The Sleeping Bear itself, which gives its name to the point, and also to the bay, is a long established dune, with an altitude of 30 meters above the terrace on which it stands, or 150 meters above the lake. This dune stands alone, and is a landmark for miles in all directions. Farther to the south, dunes are perched upon these bluffs almost continuously, and there are reasons for supposing that the Sleeping Bear is but the last remnant of such a chain of dunes formerly superposed on the bluffs near Glen Haven. Toward the east and north, as well as toward the lake, the slopes of the mesa-like formation are quite abrupt, and beyond these slopes there is to be found an extensive dune complex, the grandest in variety and beauty to be found along Lake Michigan. It seems almost certain that the source of the sand for this dune complex was an ancient row of dunes at the top of the mesa toward the west This is made more probable by the fact that the Sleeping Bear, once firmly established, is now being torn up by the winds and carried northeastward. The dune complex is moving toward the east, the line of advance being parallel to the lake shore, as usual. This advancing dune is far and away the grandest along Lake Michigan, presenting an almost continuous front, measuring four kilometers from north to south, all in active progression. The average height above the country on which it is encroaching is about 60 meters, so that it presents a most imposing sight when viewed from the fields in front of its line of advance. The dune complex at Glen Haven is like that at Dune Park, but on a far grander scale; sometimes there are hollows within it more than 30 meters in depth scooped out by the wind, and reaching down to an ancient beach. Within the dune complex there are extensive old soil lines and many scarred trunks of trees, long buried by the dunes and now resurrected, though not to life.

At many other places along the northern shore of the lake there are high bluffs of clay, or gravel, whose summits are

crowned by established dunes. Only rarely are these dunes in action at the present time, and, where such action is observed, it is clearly due to the rejuvenation of dunes that had become established. The origin of these perched dunes is obscure and hardly within the province of this paper. The formation of dunes at the summit of a bluff is not unknown. A wind laden with sand may sweep up the slopes of a hill. As it reaches the summit its path is no longer narrowly restricted, and as it spreads out, its energy is dissipated and its load deposited. However, no such action was anywhere observed; on the contrary, at many points the wind is removing the dunes from just such locations. Consequently the author rather inclines to the belief that these perched dunes represent an earlier phase of dune formation, when lake or wind conditions were different from the present. Another possible mode of origin will be discussed in connection with the rejuvenated dunes.

The greatest altitude reached by the clay and gravel bluffs is at Empire, a few miles south of Glen Haven; at this point a height of 128 meters is attained. There is a high degree of oscillation in the altitudes even within a few meters. Where the clay bluffs are highest, the perched dunes are seldom as high as where the bluffs are lower. The greatest observed height of the perched dunes above the top of the clay was 60 meters. The greatest total observed height above the lake at Empire was 162 meters; at Frankfort 153 meters. South of Frankfort and north of Glen Haven the altitudes are much less. At Charlevoix and Petoskey there are no cliffs; the dunes are low and superposed directly upon the beach.

The islands in the north end of the lake are of great interest to the student of dunes, since they are exposed to winds from all directions; the position of the dunes thus indicates the direction of the dune-forming winds. In all cases the chief dune formation is on the west coast, and the most conspicuous active dunes are usually restricted to a narrow area at or near the southwest point of each island. Observation from the steamboat revealed the presence of such dunes on South Manitou, South

Fox, and High islands. The dunes on North Manitou and Beaver islands were visited. On North Manitou there are prominent areas of dune activity along the southwest coast, the dunes being superposed on bluffs of clay or gravel. There is a flat-topped terrace here, like that at Glen Haven, but in miniature, the height being only 15 meters and the area scarcely half a hectare; the dune perched on this bluff has been rejuvenated and carried inland a few meters, the greatest altitude being 45 meters above the lake. There are also small wandering dunes superposed directly upon the beach. On the west coast the bluffs are steeper and much higher, at times perhaps 60 meters above the lake; the summits are occasionally crowned by established dunes. On Beaver island the southwest coast was not visited, but there are rejuvenated dunes at various points along the west coast, sometimes 45 meters in height; these dunes are superposed upon the beach. The beach dunes here are exceedingly varied and extensive. As previously stated, there are low beach dunes along the east coast of Beaver island. On Mackinac island there are steep clay bluffs, but no dunes. Thus, the islands plainly show that westerly winds, and especially winds from the southwest, are the chief dune formers.

Surveying the lake region as a whole, the dunes are created and shaped almost entirely by westerly winds. In the southern portions of the lake, the northwest winds have the greater sweep and are the chief dune-formers. Northward the southwest winds are the chief factors in determining the location of dunes. In intermediate localities all westerly winds contribute about equally to dune formation, and there is progressive movement of active dunes to the eastward

III. The ecological factors.

The distribution of the plants in the various dune associations is governed by physical and biotic agencies which will be considered somewhat in detail in another place. At this point it seems advisable to give a general survey of these factors, especially in so far as they affect the distribution of plant societies in the region as a whole.

LIGHT AND HEAT.

Nearly all of the dune societies are characterized by a high degree of exposure to *light*. Particularly is this true of the beach and the active dunes. The intensity of direct illumination is greatly increased by reflection; the glare of the white sand is almost intolerable on a bright summer day. The *temperature* relation is even more marked in its influence upon plant life. Because of the absence of vegetation and the general exposure of sand dunes the temperature is higher in summer and lower in winter than in most localities. This great divergence between the temperature extremes is still further increased by the low specific heat of sand. On sandy slopes protected from cold winds the vegetation renews its activity very early in the spring, because of the strong sunlight and the ease with which the surface layers of sand are heated. Willow shoots half-buried in the sand frequently develop fully a week in advance of similar shoots a few centimeters above the surface. Similarly in the autumn the activity of plant life ceases early largely because of the rapid cooling of the superficial layers of sand, as well as because of direct exposure to the cold.

WIND.

The wind is one of the most potent of all factors in determining the character of the dune vegetation. The winds constantly gather force as they sweep across the lake, and when they reach the shore quantities of sand are frequently picked up and carried on. The force with which this sand is hurled against all obstacles in its path may be realized if one stoops down and faces it. The carving of the dead and living trees which are exposed to these natural sand-blasts is another evidence of their power. Fleshy fungi have been found growing on the windward side of logs and stumps completely petrified, as it were, by sand-blast action; sand grains are imbedded in the soft plant body and as it grows the imbedding is continued, so that finally the structure appears like a mass of sand cemented firmly together by the fungus. The bark of the common osier dogwood is red on the

leeward side, but white to the windward because the colored outer layers of the bark have been wholly worn away. On the windward side of basswood limbs the softer portions are carved away while the tougher fibers remain as a reticulated network. On the leeward side of these same limbs, the outer bark is intact and even covered more or less with lichens.

The indirect action of the wind produces effects that are considerably more far-reaching than any other factor, for it is the wind which is primarily responsible for sand dunes and hence for their floras. But more directly than this, the wind plays a prominent part in modifying the plant societies of the dunes. The wind is the chief destroyer of plant societies. Its methods of destruction are twofold. Single trees or entire groups of plants frequently have the soil blown away from under them, leaving the roots exposed high above the surface; as will be shown later this process is sometimes continued until entire forests are undermined, the débris being strewn about in great abundance. Again, swamps, forests, and even low hills may be buried by the onward advance of a dune impelled by the winds; in place of a diversified landscape there results from this an all but barren waste of sand.

SOIL.

The soil of the dunes is chiefly quartz sand, since quartz is so resistent to the processes of disintegration. The quartz particles are commonly so light colored that the sand as a whole appears whitish; closer examination reveals many grains that are not white, especially those that are colored by iron oxide. With the quartz there are conspicuous grains of black sand, largely hornblende and magnetite. These black grains often accumulate in streaks, persistent for considerable depths and apparently sifted by the wind; large quartz grains are mingled with these grains of magnetite and hornblende so that it would seem as if grains of higher specific gravity are sifted out together with those of greater absolute weight. The sand of the dunes is remarkably uniform in the size of the particles as compared with beach sand; this feature is due to the selective action

of the wind, since the latter agent is unable to pick up and carry for any distance the gravel or large sand particles of the beach.

As is well known, soil made up chiefly of quartz sand has certain marked peculiarities which strongly influence the vegetation. The particles are relatively very large; hence the soil is extremely porous and almost devoid of cohesion between the grains. These features are of especial importance in their effect upon the water and heat relations as shown elsewhere. As a rule, sandy soils are poor in nutrient food materials, nor do they rapidly develop a rich humus soil because of the rapid oxidation of the organic matter.

WATER.

A factor of great importance, here as everywhere, is the water relation. Nothing need be said of atmospheric moisture, since that is sufficient to develop a rich vegetation if properly conserved, as is shown by the luxuriance of neighboring floras. Because of the peculiar physical properties of quartz sand, precipitated water quickly percolates to the water level and becomes unavailable to plants with short roots. The water capacity of sand is also slight, nor is there such pronounced capillarity as is characteristic of many other soils. Again, the evaporation from a sandy surface is commonly quite rapid. All of these features combine to furnish a scanty supply of water to the tenants of sandy soil. The rapid cooling of sand on summer nights may, however, result in a considerable condensation of dew, and thus, in a small way, compensate for the other disadvantages.

The ecological factors thus far mentioned act together harmoniously and produce a striking composite effect upon the vegetation. A flora which is subjected to periods of drought is called a xerophytic flora and its component species have commonly worked out various xerophytic structural adaptations of one sort or another. Again, a flora which is subjected to extreme cold, especially when accompanied by severe winds, takes on various structural adaptations similar to those that are characteristic of alpine and arctic floras. The dune flora is a composite flora, showing both xerophytic and arctic structures. In those

situations which are most exposed to cold winds, one finds the best illustrations of the arctic type, while the desert or xerophilous type is shown in its purest expression on protected inland sandy hills. The discussion of the various arctic and desert structures and their relations to each other will be deferred to the second part of this paper.

OTHER FACTORS.

Certain other factors are of minor importance in determining the character of the dune flora. *Forest fires* occur occasionally, and, as will be shown later, they may considerably shorten the lifetime of a coniferous plant society.

Near cities the vegetation is unfavorably influenced by *smoke* and other products issuing from chimneys. In the neighborhood of the oil refineries at Whiting, Ind., the pine trees especially have been injured or destroyed. A careful study would probably show many plant species that have suffered a similar fate.

The *topography* is often a factor of considerable importance. Dune areas are conspicuous for their diversified topography. This factor determines to a great extent the water relation which has been previously considered, the hills and slopes being of course much drier than the depressions. The topography indirectly affects the soil, since it is mainly in the depressions that humus can rapidly accumulate. The direction of slope is a matter of importance, as will be shown in discussing the oak dunes; the greater exposure of the southern slopes to the sun results in a drier soil and a more xerophytic flora on that side.

Animals do not appear to exert any dominating influences on the dune floras. The dispersal of pollen and fruits by their agency is common here as elsewhere; so, too, the changes that animal activities produce in the soil. Near the cities the influence of man is seen, although such influences are slight unless the sand is removed bodily for railroad grading and other purposes.

The influence of *plants*, which so often becomes the dominant factor, is relatively inconspicuous on the dunes. The most

important function which dune plants perform for other plants is in the contribution of organic food materials to the soil. The oxidation or removal of decaying vegetation is so complete on the newer dunes that the accumulation of humus is not important. On the more established dunes the mold becomes deeper and deeper, and, after the lapse of centuries, the sandy soil beneath may become buried so deeply that a mesophytic flora is able to establish itself where once there lived the tenants of an active dune. The advance of a wandering dune often results in the burial of a large amount of organic matter; when this matter becomes unburied years afterward it may again furnish a soil for plants. Many fossil soil lines have thus been uncovered on the Sleeping Bear dunes at Glen Haven, Mich.

IV. The plant societies.

A plant society is defined as a group of plants living together in a common habitat and subjected to similar life conditions. The term is taken to be the English equivalent of Warming's *Plantesamfund*, translated into the German as *Pflanzenverein*. The term formation, as used by Drude and others, is more comprehensive, in so far as it is not synonymous. It may be well to consider the individual habitat groups in a given locality as plant societies, while all of these groups taken together comprise a formation of that type, thus giving to the word formation a value similar to its familiar geological application. For example, one might refer to particular sedge swamp societies near Chicago, or, on the other hand, to the sedge swamp formation as a whole; by this application formation becomes a term of generic value, plant society of specific value.

Plant societies may be still further subdivided into patches or zones; the former more or less irregular, the latter more or less radially symmetrical. Patches are to be found in any plant society, where one or another constituent becomes locally dominant; zones are conspicuously developed on the beach and in sphagnous swamps. The term patch or zone has a value like that of variety in taxonomy. Authors disagree, here as every-

where, upon the content and values of the terms employed; this disagreement is but an expression of the fact that there are few if any sharp lines in nature. The above, or any other terminology, is largely arbitrary and adopted only as a matter of convenience.

In the following pages an attempt is made to arrange the plant societies in the order of development, the author's belief being that this order more faithfully expresses genetic relationships than any other. In the historical development of a region the primitive plant societies pass rapidly or slowly into others; at first the changes are likely to be rapid, but as the plant assemblage more and more approaches the climax type of the region, the changes become more slow. In the dune region of Lake Michigan the normal primitive formation is the beach; then, in order, the stationary beach dunes, the active or wandering dunes, the arrested or transitional dunes, and the passive or established dunes. The established dunes pass through several stages, finally culminating in a deciduous mesophytic forest, the normal climax type in the lake region. Speaking broadly, the conditions for plant life become less and less severe through all these stages, until there is reached the most genial of all conditions in our climate, that which results in the production of a diversified deciduous forest. On the beach there are to be found the most extreme of all xerophytic adaptations in this latitude, and, as one passes through the above dune series in the order of genetic succession, these xerophytic structures become less and less pronounced, finally culminating in the typical mesophytic structures of a deciduous forest.

A. THE BEACH.

As the author hopes to show in a subsequent paper, the beach formations of Lake Michigan are of two distinct types. One may be called the xerophytic beach, the other the hydrophytic beach. The conditions that determine these two types are not altogether clear, though their distribution suggests some factors which will contribute to the solution of the problem. Dunes are invariably absent from an area occupied by

hydrophytic beaches, partly perhaps because hydrophytic beaches are seldom sandy, and partly because they are commonly found in protected locations. The hydrophytic beaches are found where the gradient of the lake bottom is very slight; as a consequence there is a wide zone of very shallow water in which typical swamp and shallow water plants flourish in great abundance. The bottom is very thickly strewn with gravel and shingle, closely resembling a reef in structure. On the other hand, a xerophytic beach is often sandy, is commonly associated with steep clay bluffs or dunes, and the gradient is much steeper, so that there is a comparatively narrow zone of shallow water. As a consequence, wave action is much more pronounced on the beach proper, as is shown by the great amount of driftwood stranded there. The scanty flora is in striking contrast to the diversified flora of the hydrophytic beach. The greater luxuriance of the flora on the hydrophytic beach is due, in part at least, to the greater freedom from the destructive action of the waves on account of the low gradient. The water supply is also conspicuously greater on the hydrophytic beach, again chiefly because of the low gradient. Inasmuch as dunes are associated only with the xerophytic beach, no further reference will be made to the other beach type.

The xerophytic beach is essentially a product of wave action and comprises the zone which is or has been worked over by the waves. Hence the beach may be defined as the zone between the water level and the topographic form produced by other agents; in the region under study the upper limit of the beach is commonly a fringe of sand dunes or a bluff of clay or gravel. The xerophytic beach in its typical expression is very naturally subdivided into three zones, which may be called the lower beach, middle beach, and upper beach. The lower beach is that zone which is situated between the water level and the line reached by the waves of common summer storms. The middle beach is the second zone, extending up to the line reached by the highest winter storms. The upper beach is essentially a former middle beach which is now beyond the

reach of the waves, and yet is unoccupied by dunes or other topographic forms.

1. *The lower beach.*

The lower beach has been defined as the zone of land washed by the waves of summer storms. It might almost be defined as that portion of the beach which is devoid of vegetation. Perhaps there is no flora in the temperate zone quite so sparse as that of the lower beach, unless we except bare rocks and alkaline deserts. A survey of the life conditions in this zone reveals at once the reason for the scanty vegetation. Land life is excluded because of the frequency and violence of storms; the waves tear away the sand in one spot only to deposit it in another. Even though a seed had the temerity to germinate, the young plant would soon be destroyed by the breakers. Nor is there great likelihood that seeds will find a lodgment in this unstable location. As will be seen later the seeds ripened by tenants of the middle beach are almost entirely scattered away from the lake instead of toward it. The action of both wind and wave tends to carry seeds away from the lower beach. Again, few seeds could endure the alternate extremes of cold and heat, wetting and drying so characteristic of this zone.

Water life is excluded because of the extreme xerophytic conditions which commonly prevail on the lower beach. While algæ may propagate themselves in the shallow pools or even in the wet sand during a prolonged season of wet weather, a cessation of activity if not death itself soon follows the advent of dry weather. During a period of rainy weather in the autumn of 1897 green patches were observed in wet sand a few meters from the mouth of a creek near Porter, Ind. Microscopic observation showed that the green coloration was due to the presence of millions of motile Chlamydomonas forms. These unicellular biciliate algæ were in process of active locomotion in the water held by capillarity between the grains of sand. In all probability these forms migrated to the beach from the waters of the creek during a period of wet weather. It is possible that they might pass into resting stages and live through a season of drought,

were it not for the wind which gathers much of its dune material from the lower beach.

Thus the lower beach is a barren zone between two zones of life. Below it there exist algæ and other hydrophytic forms which flourish in the fury of the breakers; above it there exists the flora of the middle beach, a flora adapted to the most intense xerophytic conditions. At no particular time, perhaps, are the conditions too severe for some type of life; vegetation is excluded because of the alternation of opposite extremes.

2. *The middle beach.*

The middle beach is situated between the upper limits of the summer and winter waves, comparatively dry in summer but washed by the high storms of winter. It may also be defined as the zone of succulent annuals. The upper limit of this beach is commonly marked by a line of driftwood and débris. The instability of the beach conditions is often shown by the presence of a number of such lines, marking wave limits for different seasons. A very heavy storm will carry the débris line far up on the upper beach, to all intents and purposes carrying the middle beach just so much farther inland, as the flora of the next season testifies. Another season may be without the visitation of heavy storms and the middle beach will encroach upon the territory of the lower beach. The limits of the middle beach are altered more permanently by changes in the lower beach. In many places the lower beach is growing outwards, reclaiming land from the lake, while at other points the lake encroaches upon the land. Speaking broadly, the middle beach advances or recedes *pari passu* with the advance or recession of the lower beach. To some extent the débris lines register these changes, as their notable departure from persistent parallelism may indicate; however, there is a considerable lack of parallelism in the débris lines of a single season, owing to variations in the direction of the wind and other factors.

The life conditions in this zone are exceedingly severe, and result in a flora of the most pronounced xerophytic characters. The fury of the winter storms as they wash over the middle

beach, tearing up here and depositing there, excludes almost entirely the possibility of survival through that period. In other words, biennials and perennials are practically excluded from maturing flowers and fruits, although their vegetative structures may flourish for a single season. In the summer the xerophilous conditions are extreme. Nowhere in the dune region are the winds more severe than here; the middle beach is close enough to the lake to feel all the force of its winds and yet far enough away for the wind to pick up sand from the lower beach and bring to bear upon the flora the intense severity of the sand-blast. No flora is more exposed to the extreme desiccating influences of the summer sun than that which grows upon the bare and open beach. Even though the roots can readily penetrate to the water level, the great exposure of the aerial organs to wind and sun results in the working out of that most perfect of all xerophytic organs, the succulent leaf. Just as succulent plants inhabit deserts where no other high grade plants can grow, so, too, they are able to withstand the severe conditions of the beach.

Along the entire eastern shore of the lake, the dominant plant of the middle beach is *Cakile Americana*. At many points this succulent crucifer is almost the only plant species found in this zone, and it is always the chief character species. Two other fleshy annuals are very common tenants of the middle beach: *Corispermum hyssopifolium* and one of the spurges, *Euphorbia polygonifolia*. It is a matter of interest to observe that two of these three character plants of the middle beach, Cakile and Euphorbia, are also characteristic inhabitants of the beach on the Atlantic coast. The significance of the presence of these and other marine forms along the shore of Lake Michigan will be discussed in another place. The above plants are rarely distributed uniformly over the middle beach. The favorite place for growth is along the lines of débris previously referred to; along these lines a greater number of seeds find lodgment than elsewhere, because the waves wash them up from lower levels and the protection of the driftwood prevents the winds from

carrying them on farther. Then, too, the driftwood may furnish some protection to the growing plants, especially protection from winds which might otherwise uproot them. Cakile and Euphorbia reach their culmination on the beach, and when found farther inland it is chiefly on the upper beach or on windward slopes of active dunes. Corispermum, on the other hand, appears to be rather more characteristic of the active dunes than of the beach. Cakile is much the hardiest of the three species, venturing farther out toward the lower beach than either of the other two Of the three, Cakile is the most succulent and perhaps thus best adapted to the extreme xerophilous conditions to which beach plants are subjected. Euphorbia, however, has a copious supply of latex and its prostrate habit would seem to offer some advantages for existence on the beach. Cakile and Corispermum are readily dispersed by the wind, the latter by means of its winged seeds, while the former is a sort of tumbleweed; broken Cakile plants are common sights all over the dunes in the autumn and winter. Corispermum and Euphorbia become less and less common toward the north; at Charlevoix and Petoskey, Cakile is almost the only plant growing on the middle beach, and even this latter species is less common than farther to the south. Thus it seems as though the life conditions on the middle beach are more severe northward than southward, as indeed might be expected.

UNIVERSITY OF CHICAGO.

[*To be continued.*]

THE SOCIETY FOR PLANT MORPHOLOGY AND PHYSIOLOGY—COLUMBIA MEETING.

THE second annual meeting of the Society for Plant Morphology and Physiology was held, along with the American Society of Naturalists and the affiliated societies, at Columbia University, Tuesday to Friday, December 27 to 30, 1898. On Tuesday evening a reception was tendered to the members of the society and visiting botanists by the Torrey Botanical Club, in the rooms of the Department of Botany of the University. The society joined with the other societies in the annual discussion on Thursday afternoon (upon advances in methods of teaching), and in the annual dinner of the affiliated societies on Thursday evening. On Friday morning an excursion was made to the New York Botanical Garden, where the grounds and buildings were shown by the director, Dr. N. L. Britton. At the business sessions of the society the following officers were elected for the ensuing year: president, J. M. Macfarlane; vice presidents, G. F. Atkinson and D. P. Penhallow; secretary, W. F. Ganong. The following new members were elected: F. C. Stewart, C. O. Townsend, F. C. Newcombe, B. D. Halsted, J. B. Pollock, D. S. Johnson, L. M. Underwood, M. B. Waite. The sessions for the reading of papers were presided over by the president, Dr. W. G. Farlow. The presidential address, on "Peculiarities of the Distribution of Marine Algæ in North America," was delivered at 4:00 P.M., on Thursday. It is hoped that it will soon be published in full. The following papers were presented, the abstracts having been prepared in every case by the authors.[1]

W. F. GANONG, *Secretary.*

Some peculiar morphological structures in Paulownia imperialis: JOHN W. HARSHBERGER, University of Pennsylvania.—*Paulownia*

[1] The condensation of some of these abstracts has been necessary on account of our limited space.—EDS.

imperialis, a Japanese tree of dense umbrageous habit, is interesting botanically from several standpoints. The method of branching is sympodial. The main shoot is terminated by an inflorescence, which dies back, after the seeds are discharged, to an axillary bud that prolongs the growth the next season. The flower buds, which are grouped in dichotomous cymes approaching the scorpioid form, are protected during the winter by the fleshy calyx and dense ferruginous hairs. The flowers, which expand in spring, are fully formed within the sepals. The leaves also are hirsute, and are thus protected from the full force of the sun's rays. The fruit, which discharges in midwinter the winged seeds, is provided with a fleshy cushion that contains a considerable quantity of tannin. It is possible that this tannin is a reserve product, for when the seeds are ripe and the cushion falls out, there is not a trace of tannin left. The petiole contains a large number of crystals of calcium oxalate surrounding the hard bast. The different forms of these crystals are probably due to varying conditions of metabolism in the autumn, since the forms of crystals may be made to vary by altering the conditions of crystallization.

The life-history of Leuchtenbergia principis: W. F. Ganong, Smith College.—The life-history of this most noteworthy of the Cactaceæ has hitherto been quite unknown. Seeds and young plants obtained from Mexico have enabled the author to work out the anatomical and morphological development through all stages except that from the opened flower to the ripe fruit. The paper discusses the history of our knowledge of the species, gives a full description of it, an account of its geographical distribution, its habits and ecology, its morphological composition as determined by comparative anatomy and embryology, the precise internal anatomy of the adults, and of the parts unfolding from the vegetative points and of the embryos in their unfolding from the seed to the adults. This work is intended by the author as the first of a series of life-histories of members of this family, which are expected to yield data for a better understanding both of the phylogeny of the genera and of the principles of

morphology and ecology illustrated by this highly specialized family.

Root tubercles upon spring and autumn grown legumes: B. D. HALSTED, New Jersey Agricultural College.—The ninth successive crop of wax beans upon the same plot, grown in the spring, consisted of plants whose roots were abundantly supplied with large, nearly spherical tubercles. The plants of the succeeding crop grown in the summer upon the same soil had very few tubercles. The cause of this difference was sought in the soil conditions. During the early growth of the spring plants the soil was considerably cooler than in August when the second crop was passing through the initial stages of development. There was, doubtless, also less available soil nitrogen in the comparatively cool earth of May than in the warmer ground of August. The nitrifying germs, being more active in midsummer, provided a daily supply of combined nitrogen for the young plants. The spring crop, not having this ample supply, was "nitrogen-hungry," and this furnished the proper condition for the abundant development of the tubercles. Successful inoculation of the plants with soil-extract or the pure culture of the tubercle germ, "nitragin," is dependent largely upon soil conditions and many widely varying results may thus find an explanation.

Further notes on the comparative embryology of the Rubiaceæ: F. E. LLOYD, Teachers College.—The genera studied include Houstonia, Rubia, Sherardia, Vaillantia, Crucianella, Galium, and Asperula.

In the hypoderm of the nucellus eight or ten macrospores develop. Many of them germinate, becoming quadrinucleate. One, sometimes two, become perfect embryo-sacs, with antipodals in all forms studied, a fact hitherto unrecognized, excepting in Houstonia. One of the antipodals is very large, comprising the whole lower half of the embryo sac in Sherardia, Rubia, and Galium. The condition in Asperula is not completely clear, but the writer thinks that a larger number of antipodals are present,

as in certain Compositæ. The suspensor is divided into two regions, micropylar and embryonal. The latter is composed of disk-shaped cells; the former of large cells swollen out laterally, forming absorbing organs which become applied to the endosperm. A free preparation of these structures resembles a bunch of grapes, a condition similar to that described for Sutherlandia by Hofmeister and Guignard. The integument becomes absorbed, the seed-covering consisting of the pericarp and a single layer of cells derived from the integument.

Inflorescences and flowers of Polygala polygama: CHARLES H SHAW, University of Pennsylvania.—In addition to the well-known pink-purple aerial and subterranean cleistogamic flowers, an exactly intermediate type is developed on special inflorescences. These are green aerial cleistogamic flowers, borne on shoots which, though produced considerably above ground, are slightly or strongly geotropic. A detailed account of the differences between the three types was given.

Observations on the development of some monocotyledonous embryo sacs: R. E. B. MCKENNEY, University of Pennsylvania.—The development of the embryo-sac in two species of Scilla, *S. hyacinthoides cærulea* and *S. campanulata* was described in detail, while reference was made to Lilium. No centrosomes were observed during the resting condition of the nuclei or during mitosis.

The structure and relation of the crystal cells in sensitive plants: R. E. B. MCKENNEY, University of Pennsylvania.—The crystal cells in sensitive plants form a complete sheath around the bundle cylinder of stems and a half-sheath around the phloem side of leaf bundles. Each cell of the sheath contains a single large hexagonal crystal. The crystals seem to be rather insoluble silicates. The crystal cells have a very small enucleolate nucleus, no vacuoles, and no starch. The crystals make their appearance first in the cells at the distal end of the bundles of the first foliage leaf and are formed basipetally. The more sensitive plants have the crystals either more abundant or better developed than the less sensitive plants, and *vice versa*.

Structure and parasitism of Aphyllon uniflorum: AMELIA C. SMITH, University of Pennsylvania.—The most conspicuous features of this plant, as thus far worked out, are as follows: (1) Its parasitism on *Aster corymbosum*, and the degeneration attendant upon its parasitic habit, as expressed by: (*a*) absence of chlorophyll; (*b*) degeneration of leaves; (*c*) loss of root-hairs and probably of root-cap; (*d*) reduction and degeneration of the bundle system, and greater relative development of phloem than of xylem; (*e*) small size of seed, primitive embryo, and development of this embryo within mass of (probably) precocious endosperm. (2) Stomata, where present, are on the more exposed places, *i. e.*, outer surfaces of upper bract-leaves, upper part of flower-stalk, outer sufaces of calyx and corolla. (3) Starch is present in great quantities in roots, stems, leaves and carpellary tissue.

On the occurrence of tubers in the Hepaticæ: M. A. HOWE, Columbia University.—In none of the standard text-books does there appear to be any allusion to such structures. The number of known tuber-bearing species at the present time is at least eleven; of Anthoceros four, Riccia three, Petalophyllum two, Fossombronia one, and Geothallus one. As the Hepaticæ of the drier regions become better known this adaptation to drought will probably prove more common than now generally supposed. In the Californian *Anthoceros phymatodes*, the tuber first appears as a swelling near the apparent apex of a costa-like thickening of a thallus segment, becoming later strictly ventral through the continued onward growth of the segment, and coming at the same time to be pendent from the ventral surface through the formation of a peduncle. The body of the tuber consists of a cortex of two to four layers of nearly empty cells enclosing a mass of smaller cells so densely filled with oil-drops or nearly colorless granules that the cell-boundaries are obscure. Ashworth finds aleurone-grains and oil-drops in the interior cells of the tubers of the Australian *Anthoceros tuberosus*. The reserve food-materials in the tubers of the Californian plant seem to take the same forms. There is very little, if any, starch. In two

cases the old tubers of *Anthoceros phymatodes* have been found sending out new shoots, demonstrating that they play a part in the vegetative propagation of the plant, a function which had been only inferred in the three tuber-bearing species of Anthoceros previously known.

Morphology of the genus Viola: HENRY KRAEMER, Philadelphia College of Pharmacy.—The author has examined style and stigma, staminal and corolline hairs, pollen grains, and bracts in about thirty species of the genus Viola, chiefly found in the United States.

He distinguishes one group by its nearly globular stigma with more or less developed lip-like appendage, style with a knee-like bend, and characteristic corkscrew shaped hairs on the spurred petal. This group includes *V. heterophylla*, *V. lutea*, *V. tricolor* and its varieties.

The remaining species are subdivided into five groups, according to the length of the nectar-secreting spur of the stamen.

The influence of electricity upon plants: G. E. STONE, Massachusetts Agricultural College.—This paper contained the results of experiments based upon measurements of about 20,000 plants, and was illustrated by a dozen diagrams containing tables and growth curves showing the manner of response in plants to electrical stimuli. A brief outline of the history of electrical experiments was given, together with a discussion of the imperfections of the methods which have been employed by experimenters. Various kinds of currents were employed and data showing the relative effect of each upon germination and growth were presented. A brief résumé of some of the more important results are as follows: (1) Electricity exerts an appreciable influence upon plants. (2) The application of certain strengths of current for a short time (one minute or less) is sufficient to act as a stimulus. (3) Germination and growth are both accelerated by electricity. (4) Electrically stimulated plants do not respond immediately but possess a latent period of about twenty-five minutes, *i. e.*, about the same as that for

heliotropic and geotropic stimuli. (5) Reaction to electrical stimulation is limited to a narrow range in current intensity. The reaction is manifested either in an acceleration or retardation of metabolic activity, according to the nature or the strength of the current employed. (6) There is a minimum, optimum, cessation, and maximum stimulus. (7) The excitation produced by alternating currents is more marked than that produced by direct currents. (8) The increase of stimulus necessary to produce an equally noticeable difference of perception bears a constant ratio to the total stimulus intensity; the relationship existing between the perception and stimulus is expressed by the ratio 1 : 3 (Weber's law).

Some notes upon the germination of spores: C. O. TOWNSEND, Maryland Experiment Station.—Experiments were undertaken to determine the effect upon germination of keeping spores in distilled water under different conditions of temperature and light. Spores of Mucor, Penicillium, and other fungi were placed in test-tubes partly filled with distilled water. Some tubes were subjected to the out-door changes in temperature; others were kept at a nearly constant temperature of 18° in diffused light; others at the same temperature in the dark; and still others at 25° in the light. The spores were tested from time to time by removing a few from each set of tubes and placing them upon a mixture of gelatine and sugar in moist chambers. So long as the spores that were exposed to the natural fluctuations of temperature did not freeze they retained their ability to germinate in the usual time (12–16 hours). After freezing, however, they did not germinate. The other spores retained for at least six months their ability to germinate in the usual time. The growth of the mycelia and the ability to form new spores were not affected.

Sensitiveness of certain parasites to the acid juices of the host plants: ERWIN F. SMITH, Department of Agriculture.—The comparatively slow progress of *Pseudomonas campestris*, *P. phaseoli*, and *P. hyacinthi* when inoculated into the host plants, even in enormous

numbers, led to the belief that the restraining influence must be the acid juices of the cabbage, the bean, and the hyacinth. Experiments tend to establish this fact more definitely. All the fluids tested, hyacinth broth, cabbage juice, tomato juice, potato broth, acid beef broths, malic acid broths, etc., were titrated with caustic soda and phenolphthalein so that in each case the exact grade of acidity which retarded or inhibited growth is known definitely. This paper will soon appear in full as part of the larger work dealing with the parasitic nature and life history of Wakker's hyacinth bacterium.

Further observations on the relations of turgor to growth: CARLETON C. CURTIS, Columbia University.—Experiments were undertaken to determine the time limit for the renewal of growth after changing the concentration of the nourishing substratum, and also for testing the turgor force at the moment of renewal. Species of Mucor, Penicillium, and Botrytis were used. They were grown in respectively a nourishing solution, a nourishing solution with the addition of 4, 9, 14, and 20 per cent. KNO_3. Penicillium in the solution with no KNO_3 had a turgor force of 7.5 ($NaNO_3$ being used as a test); in a 20 per cent. solution, 42.5. In changing from 0 to 20 per cent., growth ceased for from 8 to 12 hours. When it began the turgor force in the majority of cases appeared normal, *i. e.*, 42.5. In changing from 30 per cent. to 0, growth ceased for 30 to 45 minutes, when it resumed growing at the normal turgor force (7.5). So with the lesser changes, *i. e.*, from 0 to 4 per cent., recovery occurred in about one hour, turgor force normal (12); change from 4 per cent. to 0, recovery in about 15 minutes, turgor 7.5, and so on. Botrytis gave practically the same results. Mucor was much more sensitive, having a lower turgor force, and would not tolerate a change to higher than a 4 per cent. solution, but in other respects it behaved as the others. Experiments are being conducted with other salt solutions, and also upon higher plants. As regards KNO_3 it would seem that turgor is a controlling force in growth. The check due to increasing the turgor corresponds to the shock due to cutting a hypha, inhibiting growth for a time.

Symbiosis and saprophytism: D. T. MACDOUGAL, University of Minnesota.—The terms saprophyte and holosaprophyte should be applied to those forms which derive their food supply from organic products directly, without the aid of mycorhiza, tubercles, etc. This category includes numerous bacteria, fungi, and but two seed-forming genera, Wullschlægelia, and Cephalanthera. The last named has been added by recent investigations of the author. The extension of the saprophytic capacity of seedlings results in the reduction of the seeds, and may also be prolonged to include the entire life history of the sporophyte.

Influence of inversions of temperature and vertical air-currents upon the distribution of plants: D. T. MACDOUGAL, University of Minnesota.— As a consequence of the rapid radiation from the soil and low conductivity of dry air, the lower layers of air are cooled much more rapidly than the upper layers. In broken regions the cooled air flows down into the valleys, giving them a lower minimum than that at the adjoining hills. The diurnal ascending currents give the hills a lower maximum than the valleys. A valley at Flagstaff, Ariz., showed a temperature 15 to 27° F. below that of an adjoining hill at night, and was 3 to 5° warmer in the day. As a consequence, the average temperature of the valley will be lower than that of the adjoining hills, and the temperature of the hills will be more equable than that of the valley, provided the difference in elevation be less than 1000ft. At this and greater differences of height the disturbing factors of increased insolation, effect of altitude, and expansion and compression of the atmosphere come into play. The expansion and cooling of ascending currents of air increase their humidity, and thus give certain local ridges and rims of mesas a comparatively moist atmosphere. According to the laws of influence of temperature upon distribution, and supported by observations of the writer in the southwest, also by the results of Professor Townsend, the following conclusions are reached: (1) Inversions of temperature and resulting air-currents give minor highlands a much more equable temperature than adjoin-

ing hills and cañons. In North America such effects are most marked on the elevated plains of the southwest. (2) Inversions of temperature would result in major deflections of zonal boundaries on great level plains, and constitute a hitherto unrecognized factor in distribution. (3) Inversions of temperatures and the resulting air-currents cause abrupt deflections of the zonal boundaries corresponding to minor topographical features. Southern forms reach their extreme northernmost extension along ridges and hills. Northern forms penetrate farthest southward down valleys or cañons. (4) Ascending currents of air furnish conditions favorable to the growth of moisture-loving species along the margins of table lands bordering on valleys and cañons.

Some appliances for the elementary study of plant physiology: W. F. GANONG, Smith College.— The author pointed out that investigation is greatly aided by the wide diffusion of its results through good elementary teaching, and that the rapid introduction of plant physiology into elementary courses in botany is making a demand for simpler, less expensive and more conclusive experiments. The author then described some simple appliances developed in his physiological practicum in Smith College. These included a simple temperature stage for study of the relation of temperature to protoplasmic movement, by use of which very accurate quantitative results may be obtained; a clinostat constructed from clockwork and ample for demonstrating the principles of geotropism, etc.; a self-recording auxanometer, simple and inexpensive but yielding sufficiently accurate results for elementary work; an osmometer, using Schleicher & Schüll's diffusion shells 16^{mm} diameter in combination with burettes, giving very pronounced results; a simple new method of demonstrating the exchange of gases in respiration; an inexpensive germination box; a useful way of preparing a plant for transpiration experiments; an excellent way of graduating roots, etc., by the use of a stretched thread along which insoluble India ink is allowed to run by capillarity. A description of these appliances will be published later.

Some notes on the reproduction and development of Nereocystis: CONWAY MACMILLAN, University of Minnesota.—(Abstract not furnished.)

The formation and structure of the dissepiment in Porothelium: E. A. BURT, Middlebury College.—The author traced the development of the fructifications of *Porothelium fimbriatum* Pers. from their origin as papillæ, through the pore, to the tube stage; in the latter stage contrasting the structure of the dissepiment where the tubes are closely crowded together with its structure where they are more scattered.

Gelatin culture media: ERWIN F. SMITH, Department of Agriculture.—Dr. Smith spoke on gelatin culture media, illustrating his remarks by photographs, charts, etc. The behavior of many sensitive organisms, particularly parasites, depends entirely on how the nutrient gelatin is compounded, and consequently this should always be stated. (1) The melting point of nutrient gelatins increases as more gelatin is added. It decreases on addition of acids and alkalies and by long boiling. (2) Grape sugar or cane sugar added to nutrient gelatin frequently restrains or entirely prevents liquefaction, while at the same time it stimulates growth. For this reason gelatin should be made with beef broth free from sugar. (3) Owing to the fact that commercial gelatin contains acid salts, which are neutral or alkaline to litmus but retard the growth of many organisms, the gelatin media should first be rendered neutral to phenolphthalein, after which, if desired, it may be acidified with particular acids. A commercial gelatin of uniform character and washed free from all inhibiting acid substances is a desideratum.

Notes on the relative infrequence of fungi upon the trans-Missouri plains and the adjacent foothills of the Rocky mountain region: CHARLES E. BESSEY, University of Nebraska (Abstract presented by ERWIN F. SMITH).—In the districts named a study of fourteen years has shown the species of fungi to be numerous, while the number of individuals is comparatively small, the exact opposite being true of the flowering plants, especially of her-

baceous sorts. This scarcity of individuals is especially marked in case of the higher fungi.

Different types of plant diseases due to a common Rhizoctonia: B. M. DUGGAR, Cornell University, and F. C. STEWART, New York Experiment Station.—A number of species of the sterile fungus Rhizoctonia have long been known as root parasites on a wide range of host plants. (1) Studies on a damping-off fungus of various seedlings have located the cause of the disease as a species of Rhizoctonia. (2) A fungus agreeing in structure with the latter has been the cause of a serious root-rot of sugar beets in New York during the past year, and the fungus identified with this disease seems to be undoubtedly *Rhizoctonia Betæ* Kühn. (3) An important stem-rot of carnations is also found to be due to a fungus agreeing precisely in its characters with the beet Rhizoctonia.

That the organism mentioned in each case is the cause of the trouble indicated has been demonstrated by experiment. Again, there is abundant experimental proof showing that the beet fungus and the carnation fungus are identical. The last named fungi also produce damping off, although not so abundantly as the fungus originally isolated from damped-off seedlings. Experiments, however, indicate that these different types of diseases are all due to the same species of Rhizoctonia, the specific affinities of which cannot now be given with certainty. Peculiarities in branching, and the formation of tuft-like masses of hyphæ, or of sclerotia, readily identify this fungus. Its sensitiveness to alkaline nutrient media suggests the preventive treatment.

The stem-rot diseases of the carnation: F. C. STEWART, New York Experiment Station.—Under the names "stem-rot," or "die-back," at least two distinct diseases have been confused. One is caused by Rhizoctonia; the other is due to a Fusarium, and is, perhaps, identical with Sturgis' carnation stem-rot. Both diseases are common in the field and greenhouse.

The Fusarium attacks chiefly the stem and larger branches,

discoloring the wood and killing the cortex, but rarely causing a soft rot. The affected plants die gradually with yellowing and drying of the foliage. The fungus rarely fruits on the outside of the stems, but more frequently in the cambium and pith of stems long dead.

The Rhizoctonia causes the plants to wilt suddenly by rotting the stem at or just below the surface of the soil. The cortex readily separates from the wood, the pith is attacked quite early, becoming water-soaked in appearance (corky when dry) and filled with hyphæ.

BRIEFER ARTICLES.

NOTES ON THE MAXIMUM THERMAL DEATH-POINT OF SPOROTRICHUM GLOBULIFERUM.

WHILE engaged in a study of an entomogenous fungus, *Sporotrichum globuliferum*, as an economic factor in the destruction of the chinch-bug, some experiments were made for the determination of the maximum thermal death point of this fungus under various conditions. The experiments were necessarily concluded when only some of the more evident results of higher temperatures had been secured as preliminary to more accurate investigations. Since it proved impossible to continue this work much further under similar conditions, some preliminary data are presented which are at least suggestive at times.

The original culture of the fungus was secured from a beetle, and the fungus is undoubtedly that which has been determined by Thaxter[1] as *Sporotrichum globuliferum* Speg. The cultures used in this experiment are one remove from stock tubes secured from the above mentioned dilution culture. All cultures were made on nutrient agar in slanting tubes, and every lot exposed to high temperatures was accompanied by checks at the room temperature. Since the checks constantly gave uniform growth, they are not included. Moreover, exposed tubes in which growth had failed were constantly re-inoculated and tested at room temperatures, and in all cases growth resulted.

In estimating quantity of growth it is difficult, with such tube-culture experiments, to make close comparisons in any case, and especially so where there is no distinct line of growth, but only several isolated centers. All sowings were made as streak cultures with an abundance of spores on the needle, and discrepancies might occasionally arise from the fact that spores adhering in small masses might be less penetrated by moisture, and hence more liable to survive.

In general, the approximate length of exposure required to cause death at the various temperatures is plainly indicated in the tables, and comment is unnecessary. Some details, however, may be noticed in connection with the tables.

[1] Seventeenth Report of the State Entomologist of Illinois, S. A. Forbes, 1895–6.

From drop cultures it was ascertained that germination might begin in a few hours; and in twenty-four hours there was considerable germination and growth about the spores. Again, at a uniform temperature, in two and one-half days, considerable aerial mycelium was developed, but rarely any spores, and this stage of growth was taken as the age limit for tests upon mycelium. (See table VI.)

For the tests with dry spores, as in table VII, fresh spores were exposed on glass slips, and then inoculations were made immediately therefrom.

TABLE I.

35° C. AGAR CULTURES.

Exp. no.	When exposed, after sowing	Length of time exposed	Successive days	Result
1	Immediately	6 hours		Good growth
2	"	24 "		One center
3	"	Continuously		No growth
4	6 hours	24 hours		Good growth
5	24 "	24 "		Good growth
6	Immediately	6 "	2	Good growth
7	"	6 "	4	Good growth

It is of some interest that even at 35° an exposure of 24 hours quite effectually inhibits growth, when immediately exposed to this temperature (see exp. 2); while a few hours after germination may have begun, the same did not hold true.

TABLE II.

37.7° C. AGAR CULTURES.

Exp. no.	When exposed, after sowing	Length of time exposed	Successive days	Result
8	Immediately	6 hours		Good growth
9	"	9 "		Good growth
10	"	18 "		Good growth
11	"	24 "		No growth
12	"	Continuously	One week	No growth
13	6 hours	24 hours		Good growth
14	15 "	24 "		Good growth
15	24 "	24 "		Good growth

The results at 37.7° C. repeat and confirm those of table I, in that freshly sown spores are readily killed in twenty-four hours, while those

which have lain some hours in conditions favorable for germination are capable of further growth after exposure.

TABLE III.

40.5° C. AGAR CULTURES.

Exp. no.	When exposed, after sowing	Length of time exposed	Successive days	Result
16	Immediately	6 hours		Good growth
17	"	9 "		Good growth
18	"	18 "		Good growth
19	"	24 "		No growth
20	"	Continuously		No growth
21	6 hours	6 hours		Good growth
22	15 "	6 "		Good growth
23	24 "	6 "		Good growth
24	6 "	24 "		One center
25	15 "	24 "		Two centers
26	24 "	24 "		No growth
27	Immediately	3 "	2	Two centers
28	"	3 "	4	No growth
29	"	6 "	2	No growth
30	"	6 "	4	No growth

TABLE IV.

46.1° C. AGAR CULTURES.

Exp. no.	When exposed, after sowing	Length of time exposed	Successive days	Result
31	Immediately	1 hour		Good growth
32	"	3 hours		Few centers
33	"	6 "		No growth
34	"	9 "		No growth
35	"	18 "		No growth
36	6 hours	1 hour		Good growth
37	15 "	1 "		Good growth
38	24 "	1 "		Good growth
39	6 "	3 hours		Fair growth
40	15 "	3 "		Good growth
41	24 "	3 "		Good growth
42	6 "	6 "		One center
43	15 "	6 "		Three centers
44	24 "	6 "		Six centers
45	6 "	12 "		Three centers
46	15 "	12 "		Four centers
47	24 "	12 "		No growth
48	6 "	24 "		No growth
49	15 "	24 "		One center
50	24 "	24 "		No growth
51	Immediately	1 hour	2	No growth
52	"	1 "	4	No growth

TABLE V.

51.6° C. AGAR CULTURES.

Exp. no.	When exposed, after sowing	Length of time exposed	Successive days	Result
53	Immediately	1 hour		Four centers
54	"	3 hours		No growth
55	"	6 "		No growth
56	6 hours	1 hour		Six centers
57	15 "	1 "		One center
58	24 "	1 "		No growth
59	6 "	3 hours		One center
60	15 "	3 "		No growth
61	24 "	3 "		No growth
62	6 "	6 "		No growth
63	15 "	6 "		No growth
64	24 "	6 "		No growth
65	Immediately	1 hour	2	No growth
66	"	1 "	4	No growth

TABLE VI.

MYCELIUM, AGAR CULTURES.

Exp. no.	When exposed, after sowing	Length of time exposed	Temperature, deg. C.	Successive days	Result
67	2½ days	6 hours	37.7		New growth
68	2½ "	24 "	37.7		New growth
69	2½ "	6 "	40.5		New growth
70	2½ "	24 "	40.5		New growth
71	2½ "	6 "	40.5	2	Four centers new growth
72	2½ "	6 "	40.5	4	No new growth
73	2½ "	1 hour	46.1		New growth
74	2½ "	3 hours	46.1		New growth
75	2½ "	6 "	46.1		Fair new growth
76	2½ "	12 "	46.1		Three centers new growth
77	2½ "	24 "	46.1		No new growth
78	2½ "	1 hour	46.1	2	New growth
79	2½ "	1 "	46.1	4	Few centers new growth
80	2½ "	3 hours	46.1	2	New growth
81	2½ "	3 "	46.1	4	One center new growth
82	2½ "	6 "	46.1	2	One center new growth
83	2½ "	6 "	46.1	4	No new growth
84	2½ "	1 hour	51.6		New growth
85	2½ "	3 hours	51.6		New growth
86	2½ "	6 "	51.6		No new growth
87	2½ "	12 "	51.6		No new growth
88	2½ "	24 "	51.6		No new growth
89	2½ "	1 hour	51.6	2	No new growth
90	2½ "	1 "	51.6	4	No new growth

Table III shows less difference between immediate and delayed exposures to the higher temperature.

In table IV it is again evident that longer exposures were necessary to kill all of the spores when germination might have begun.

The limits of growth in table V are very well indicated, and the effects of immediate and delayed exposures are for the first time practically the same.

TABLE VII.

SPORES EXPOSED TO DRY HEAT.

Exp. no.	Length of time exposed	Temperature	Successive days	Result
91	6 hours	51.6		Good growth
92	3 "	54.4		Good growth
93	6 "	54.4		Good growth
94	1 hour	60		Good growth
95	6 hours	46.1	2	Good growth
96	6 "	46.1	4	Good growth
97	3 "	51.6	2	Ten centers of growth
98	3 "	51.6	4	No growth

Unfortunately the maximum amount of dry heat which the spores of this fungus will resist during a single exposure was not ascertained.

Below are given some results at various temperatures with the mycelium of this fungus when grown upon chinch-bugs.

TABLE VIII.

MYCELIUM, CULTURES ON INSECTS.

Exp. no.	Growth	Length of time exposed	Temperature Deg. C.	Successive days	Result
99	Mycelium	6	46.1		New growth on some
100	"	24	46.1		New growth on some
101	"	3	46.1	4	New growth on some
102	"	6	46.1	4	New growth on some
103	"	3	51.6		New growth on all
104	"	6	51.6		New growth on some
105	"	1	51.6	4	New growth on some
106	"	3	51.6	4	New growth on all

In the experiments of table VIII, a number of dead bugs were dusted with the spores, and in a day or so, when there was considerable aerial growth of mycelium along the body sutures, exposures were

made. The thermal death point was not ascertained, but it is evidently much above that of the mycelium grown upon agar (see table VI). The fact that new growth, or further growth, did not appear upon some of the insects was expected, since sterilization precautions could not there be observed, and foreign molds were sometimes present.— B. M. DUGGAR, *Cornell University, Ithaca, N. Y.*

DESCRIPTIONS OF TWO WILLOWS FROM CENTRAL MEXICO.

(WITH FIGURES 1, 2.)

THE two willows here described were collected by Mr. Pringle at Sierra de Ajusco in the state of Mexico. They were collected at an altitude of 10,000 feet. The descriptions of Mexican willows are meager and imperfect. Anderson in the Prodromus gives them very little attention, probably having only scanty material from that region, and with very little literature from which to make up descriptions.

The writer wishes to express his gratitude to Dr. Robinson and Mr. Greenman of the Gray Herbarium not only for the opportunity to study the specimens but also for much information regarding the Mexican species.

Salix Pringlei, n. sp.— Shrub 1 to 2^{m} high: twigs of season's growth minutely hoary puberulent, older shoots dull olive green or brownish: leaves in vernation densely tomentose and slightly ferruginous, at maturity becoming nearly glabrous and dark green above, paler and velvety tomentose beneath, entire (or obscurely crenate on vigorous young shoots), elliptical, acute at both ends, largest 6^{cm} by 2^{cm}, on petioles 5^{mm} long; stipules none: pistillate ament at anthesis nearly sessile in its leafy bracts, 2^{cm} long by 1^{cm} thick, subcylindrical: young capsule ovate-lanceolate, densely tomentose, grayish, 3^{mm} long, very short pedicelled; scale twice the length of the pedicel, elliptical, black, with rather long crisp hairs on its margin; gland small, one-half as long as the pedicel; style very short; stigmas bifid: pistillate aments at maturity large (6–8^{cm} long by 2^{cm} thick), on short leafy peduncles less than a centimeter long bearing 3 or 4 small green leaves: mature capsules lanceolate conical on glabrous pedicels.

This description is based on Mr. Pringle's no. 6795. No staminate plant was collected. The species is related to *S. candida* which it

resembles in the general characters of the ament and the aspect of the whole plant. It differs from that species, however, in having broader leaves, not at all revolute nor rugose, no stipules, pedicel longer than the gland, style and stigmas relatively short. *S. paradoxa* Kunth differs from this species in having "capsulæ hirsutæ longe pedicellatæ, stylo nullo."

S. CANA Mart. & Gal.—Tree 5–7^{m} high: twigs scantily canescent, older shoots stout black and glabrous: leaves in vernation densely flocculent tomentose, becoming glabrous or nearly so when mature, green above, glaucous and prominently veined beneath, obovate or elliptical, apex acute or short acuminate, acute or rather abruptly contracted at base, entire, largest 6^{cm} long by 2^{cm} wide; petioles hairy, 5^{mm} long; stipules minute or wanting: staminate aments large (3^{cm} by 1^{cm}); stamens two, filaments hairy below; scale obovate, apical half dark brown, ciliate; gland large, one half as long as the scale: mature pistillate aments large (7^{cm} by 2^{cm}), nearly sessile; peduncle at maturity only 1^{cm} long and bearing four or five small leaves, rather closely flowered; full grown capsule (8^{mm} long) ovate-conical, glabrous, minutely roughened; pedicel (2^{mm}) hairy, gland less than one-half the length of the pedicel; bract oblong, slightly longer than the pedicel; style short (0.5^{mm}). A capsule aborted at anthesis indicates that the bract is then about twice the length of the pedicel.

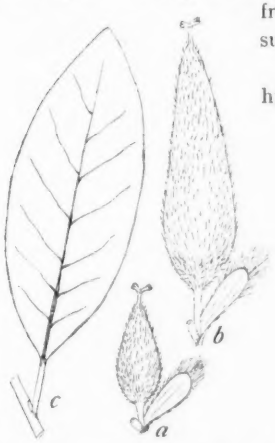

FIG. 1.—*Salix Pringlei*. *a* young capsule, with scale and gland; *b* mature capsule; *c* leaf.

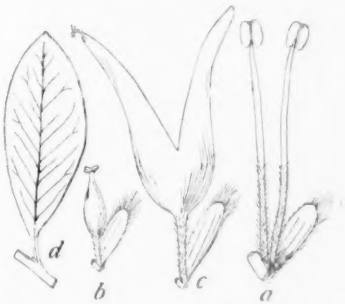

FIG. 2.—*Salix cana* Mart. & Gal. *a* ♂ flower; *b* young capsule; *c* mature capsule, dehisced; *d* leaf.

The original description of this species, as given in *Bull. Acad.*

Brux. 10: —, is based on a leafy specimen, the authors' own statement being "amenta ignota." Their description does not disagree with our plant, and the fact that both were collected in the same region and approximately at the same altitude, warrants the conclusion that they belong to the same species.

As will be seen, the above description is drawn from a staminate branch at anthesis and a pistillate branch when the capsules are mature. They are Mr. Pringle's no. 6794.

This species belongs to the *Cordata* group and is closely related to *S. lasiolepis* of California, from which it differs in having free hairy filaments, hairy pedicels, elliptical leaves, and large catkins.—W. W. ROWLEE, *Cornell University*.

A PECULIAR CASE OF SPORE DISTRIBUTION.

(WITH FIGURE 1.)

THE manner in which the spores of fungi may be distributed is clearly shown in a case which came under observation last September, in Columbus, Ohio. A grape vine, quite thoroughly infested with the mildew, *Uncinula necator* (Schw.) Burr., showed its characteristic circular spots in profusion. This was the condition over about two-thirds of the one affected vine, and the appearance of these leaves is shown in *a*, *fig.* 1. In the remaining third of the leaves the fungus forsakes its habit of concentric growth and follows a tortuous path, of the greatest irregularity and grace, as shown in *b* and *c*, *fig.* 1. A microscopic examination proved the fungus to be identical in the two cases, and the explanation of its diversity of habit must be sought in the mode of infection of the leaf surface. Holding the leaf in the light one can see, extending even beyond the fungus in its onward march, a glistening track ready for its approach. The peculiar gleam and the characteristic windings are almost proof that it was made by some animal crawling over the leaf and leaving a trail of its glutinous secretion. Sections show the track to be purely superficial, and we are led to conclude that this animal, be it worm or snail, has first visited leaves bearing mature asci and spores or conidia, and then, with its body laden with them, has crawled over another leaf in a tortuous path, freely sowing the spores, which promptly develop. The resulting white mycelium and conidia plainly mark the track.

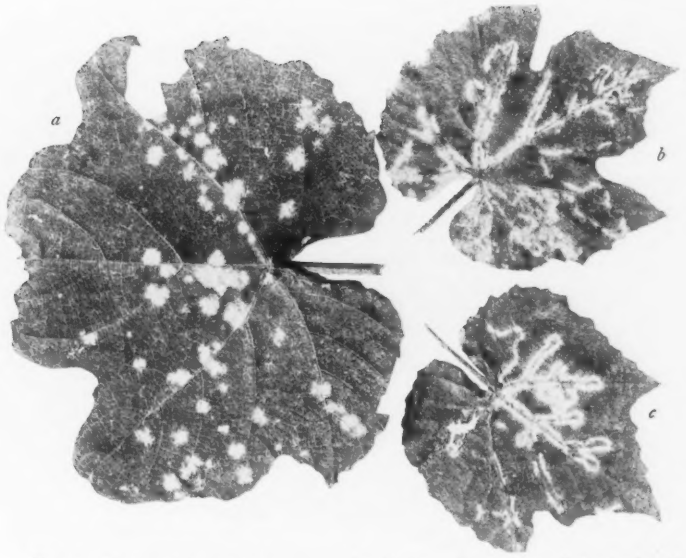

FIG. 1.—LEAVES OF GRAPE VINE; *a* showing usual infection of Uncinula; *b*, *c* showing infection, by crawling animal.

The photograph from which the figures were made was kindly prepared by Mr. M. B. Griffith of Columbus, Ohio.— F. L. STEVENS, *The University of Chicago.*

A NEW SILPHIUM.

Silphium lanceolatum, n. sp.— Stems about three feet high, slender, glabrous, striate, bearing a few small partly clasping bracts: leaves all at or near the base of the stem on long and slender petioles, lanceolate in outline, acute at summit, and very tapering at the base, thin but coarse, somewhat undulate toothed or nearly entire, four to eight or more inches long, the edges and midrib beneath somewhat hairy, otherwise smooth: heads few (one to three as far as seen), terminating the long slender branches or main stem, the former of which are bracteate at base and bibracteate an inch or two above: involucres very smooth, the outer scales orbicular, the inner (three or four) oblong and twice as long as the outer, obtuse and thin at summit: achenia broadly

obovate, narrowly winged, having a broad and shallow emargination at summit without cusps; rays not seen.

Collected on Chickamauga battlefield, Georgia, October 6, 1898.

The affinity of this plant is with *S. terebinthinaceum*, from which, however, it is very different. It is evidently more nearly allied to Elliott's *S. pinnatifidum*, which I have not seen, but it does not agree with his description.—WM. M. CANBY, *Wilmington, Del.*

OPEN LETTERS.

IMPERFECTIONS OF LABORATORY MATERIAL

THE experimenter must be keenly alive to possible imperfections of the material of which his apparatus is constructed, a fact made apparent by a recent experience in this laboratory with a bleeding-pressure demonstration. The demonstration consisted of a T-tube filled with water, attached to the stump of a plant, and to the short arm an open manometer, filled with mercury. The pressure of the exuding sap set up a difference of level between the columns of mercury in the arms of about 8^{cm}. After this point had been reached the mercury remained stationary and the sap appeared to be passing the mercury in some manner, as it appeared in an increasing amount on top of the mercury in the free arm of the manometer, finally filling it and overflowing at a height of 60^{cm}. This puzzling action was explained by the fact that the manometer tube showed a minute groove throughout its entire length on the inner side of the wall so small that it could not be entered or filled by the mercury. This permitted a constant stream of water to pass by into the other arm of the manometer. Of the many things which may occur to disconcert the beginner in studying root-pressure, the above is doubtless one of the most unusual.—D. T. MACDOUGAL, *University of Minnesota.*

CURRENT LITERATURE.

BOOK REVIEWS.

Vines' "Elementary text-book."[1]

THIS book was prepared to meet a demand for a less bulky and expensive volume than the author's *Students' text-book of botany*. So far as bulk is concerned, the present volume contains about 200 pages less than the former, and simplification has taken the form of omitting certain "difficult and debatable topics, such as the details of nuclear division, and the alternation of generations in the thallophytes."

As before, the book is divided into four parts, Morphology, Anatomy and Histology, Physiology, and Classification. The author lays no special stress upon the sequence of parts, stating that the different parts should be studied together, but he has concluded to let Physiology precede Classification, instead of following it, as in the *Students' text-book*.

The first three parts contain clear and compact statements of the general facts of morphology, anatomy, and physiology, as the author defines these subjects. As morphology is usually studied, however, its most essential facts are placed by the author under "classification." In fact, the morphology, as here presented, is impossible of comprehension without some knowledge of life histories, and of the evolution of organs as presented by different plant groups. The reviewer questions the advantage of presenting morphology to elementary students apart from plant groups.

The part devoted to physiology contains but seventy-six pages, and, of course, is an excellent presentation of what may be called physiology proper, or that phase of physiology which deals with life processes; but it is to be regretted that no mention is made of that phase of physiology which deals with life relations, the phase which we have come to call ecology. This subject has had sufficient development to demand treatment in any elementary text-book, and a few pages given to it could well have been spared from the dreary waste of angiosperm families (occupying nearly 100 pages), which no elementary student uses or can use to advantage.

In the fourth part, the first notable change is the recognition of gymnosperms as an independent group, which is certainly justifiable. Hence, the old group "phanerogams" or "spermatophytes" disappears, being replaced

[1] VINES, SYDNEY H.: An elementary text-book of botany. 8vo. pp. xv + 611. The Macmillan Company: New York. 1898. $2.25.

by gymnosperms and angiosperms. In spite of this change, however, the general characters of gymnosperms and angiosperms are discussed together under the heading "Phanerogamia." On account of the great differences between the groups this composite presentation is very confusing, and can hardly be justified by the fact that they both produce seeds. It would have been far less misleading, as well as clearer, had the two groups been kept consistently apart.

The thallophytes are treated as before, all of them being either algæ or fungi; and the treatment of each one of these divisions follows the old artificial method, convenient for simple presentation, but very misleading as to the facts of genetic relationship. It must be confessed that the treatment of thallophytes in this volume and in its predecessor does not represent our knowledge of the group. The account of the fungi especially is to be criticised. In the Filicineæ we note that the author bases his main divisions on eusporangy and leptosporangy, rather than upon homospory aad heterospory, as in the former volume, a change more in accord with the present conceptions of the group.

The classification of angiosperms, however, can hardly be excused on any plea. Why the classification of Bentham and Hooker's *Genera Plantarum* was persisted in, in view of all that has been done since to increase our knowledge of this group, is something of a mystery. A certain amount of conservatism is wise in a text-book, especially in an elementary one, but there is a difference between conservatism and the perpetuation of a classification which has been outgrown.— J. M. C.

The flora of Roumania.[2]

BOTANISTS unfamiliar with Roumanian will be restricted to the names of plants in their use of this book. In the presentation of a flora, however, plant names represent no small amount of information. Only the spermatophytes and pteridophytes are included, and the classification is of the old type, as the division of dicotyledons into "dialypetalous," "gamopetalous," and "apetalous" series would indicate. Probably the most startling evidence of antiquity, however, is the inclusion of Gnetaceæ and Coniferæ among the families of apetalous dicotyledons!

The work is not a descriptive flora, but a list, with full bibliography, geographical distribution, and critical remarks. Unfortunately, the descriptions of new species are in the vernacular, instead of Latin. Over one hundred pages are devoted to a discussion of the geographical distribution of the plants of Roumania, which probably is the most interesting and important feature of the book.

[2] GRECESCU, DR. D.: Conspectul Florei Romaniei. 8vo. pp. xvi + 836. Friedländer & Sohn: Berlin. 1898. *M* 12.

Certain statistics in reference to the flora are of general interest. The overwhelming preponderance of dicotyledons is shown in the following enumeration: dicotyledons 2109, monocotyledons 447, gymnosperms 11, pteridophytes 35. The largest families are Compositæ (328 spp.), Gramineæ (182), Leguminosæ (146), Caryophyllaceæ (141), Cruciferæ (139), Rosaceæ (124), Labiatæ (109), Umbelliferæ (109). Certain families are conspicuous by their poor representation, as Malvaceæ (11 spp.), Ericaceæ (14), Asclepiadaceæ (3), Polemoniaceæ (1), Acanthaceæ (1), Verbenaceæ (2). The large genera are Carex (55 spp.), Hieracium (38), Centaurea (35), Veronica (31), Ranunculus (29), Dianthus (27), Silene (27), Trifolium (27), and Galium (25). Aster is represented by but four species, and Solidago by one. Festuca is the largest genus of Gramineæ, and Verbascum of Scrophulariaceæ. Aside from the grasses and sedges, the monocotyledons form little more than 6 per cent. of the vascular flora.— J. M. C.

The flora of the West Indies.[3]

UNDER the editorship of Dr. Urban we are promised a valuable work on the flora of the West Indies. This very important region has been in the possession of so many governments that the literature of the flora is badly scattered. It is a great boon to botanists to have it brought together in compact form. The work will be of especial value to American botanists, who are largely interested in the study of the flora of Mexico and the Central American states.

This first part is by Dr. Urban himself, and is a remarkably complete and painstaking bibliography. Not only is the literature of the region presented, but under each title is a synopsis of the contribution, so that one may know just how important a publication each title represents. At the close of the part is a conspectus of the literature by islands and also by plant groups. It would seem as if any published botanical information in reference to any island or plant group can at once be discovered in this remarkable bibliography.

The work will be issued in parts at indefinite intervals, each part containing about 160 pages, and three parts forming a volume. The subscription price will vary from $2 to $3 for each part.— J. M. C.

Nature study.

THE increase of interest in nature study has called forth a large number of publications intended to assist teachers and pupils in this work. Many of these have been little more than compilations of fantastic stories about natural

[3] URBAN, IGNATIUS: Symbolæ Antillanæ seu fundamenta floræ Indiæ occidentalis. Vol. I. Part I. Bibliographia Indiæ occidentalis botanica. 8vo. pp. 192. Fratres Borntraeger: Berolini. 1898. *M* 10.80.

objects, made by persons with excellent imaginations and a little inaccurate information upon several scientific subjects. As a result nature study is looked upon, in some localities, as a rather frivolous pastime, which is not of any very great importance in the real business of education. There are several books, however, which do not attempt to show that all animate objects are spectacular, but rather attempt to direct attention to the manifestations of life in our everyday contact with it. It is to the latter kind of helps that Mr. D. Lange's excellent book belongs.[4]

The guiding principle of the book has been that pupils must see and examine real objects, not merely their pictures and descriptions. The lessons are planned with the idea of having pupils obtain their knowledge at first-hand so far as possible. Part of the work is arranged with reference to seasons, as "Life about our homes in the fall," and "Some forest trees in their winter conditions," while other sections deal with particular subjects, *e. g.*, "Geological action of water." Lessons about many of the common plants, birds, and mammals are presented in such an attractive style that even very young pupils will doubtless be entertained and instructed by following them. The author's aim is primarily to cultivate habits of observation; incidentally the pupil will obtain a great deal of valuable information.

The author says that in order to do good work it is not necessary that the teacher shall have taken a course in botany, zoology, or geology. It is possible that much good work may be done by some teachers who have not had such opportunities; however, it is beyond doubt that elementary science work in primary and secondary schools has suffered very greatly at the hands of teachers who have attempted to teach science subjects without having the necessary preparation for it. The book under discussion will certainly do much toward assisting weak teachers, but we insist that nothing short of thorough instruction in these sciences, added to ability to teach, can make teachers fully competent to handle nature study.—O. W. CALDWELL.

A satisfactory work on fertilizers.

THE marked increase in the use of commercial fertilizers in the United States has given rise to a demand for reliable information regarding the composition and utility of such goods. The official reports of those states which have laws regulating the sale of fertilizers give abundant analyses of mixed goods actually on the market, but the limits of such reports prevent any full discussion of the questions which arise in practice. A great mass of matter has been written in regard to feeding both plants and soils. Much of this matter is in the form of special pleading for some particular "system," and very little of it is recent or applicable to American conditions. The practical

[4] LANGE, D.: Handbook of nature study. For teachers and pupils in elementary schools. 12mo. pp. xvi + 329, *figs. 60*. The Macmillan Company: New York. 1898.

worker and the investigator in field, garden, or greenhouse, felt the need of some reliable work dealing in a plain way with the principles and practice involved in economical plant feeding. Such a work has been supplied by Professor Voorhees,[5] who has the happy faculty of telling what one wants to know, and telling it briefly. One is told what to do and given a reason for doing it, and due consideration is given to modifications required by special or unusual conditions.

The description of fertilizing material is up to date, and the formulas recommended for special crops are those that have been profitable in actual use; not the oft-reprinted ones that can be traced back only to advertising matter.

In addition to the specific information in regard to feeding plants, the botanist will doubtless welcome the clear, brief summary of the several broad systems of fertilization that have been proposed and advocated at great length by their authors.

The author is too genial to be accused of being a philosopher; but here and there he drops a remark that sets one to thinking of the broad questions involved in the production of plants, and then speedily leads one to see how the principles discussed can be reasonably and profitably applied.

The book will receive a hearty welcome from both investigator and farmer. — H. A. HUSTON.

MINOR NOTICES.

THE FIRST NUMBER of *Rhodora*, the journal of the New England Botanical Club, has made its appearance. The editorial staff is as follows: B. L. Robinson, editor-in-chief; F. S. Collins, M. L. Fernald, and H. Webster, associate editors; W. P. Rich and E. L. Rand, publication committee. The purpose is tersely stated as follows: "This journal is founded by the New England Botanical Club, with confidence that it will give new stimulus and render material aid to the study of our local flora. . . . In the selection of subject-matter, special attention will be given to such plants as are newly recognized or imperfectly known within our limits, to the more precise determination of plant ranges, to brief revisions of groups in which specific and varietal limits require further definition, to corrections upon current manuals and local floras, to altitudinal distribution, plant associations, and ecological problems."

The first number contains the following papers: "Rattlesnake plantains of New England," by *M. L. Fernald;* "Saniculas of western Vermont," by

[5] VOORHEES, EDWARD B. — Fertilizers: The source, character, and composition of homemade and manufactured fertilizers; and suggestions as to their use for different crops and conditions. 12mo. pp. xiv + 335. New York: The Macmillan Company. 1898. $1.00.

E. Brainerd; "Notes on algæ," by *F. S. Collins;* "A prolific gentian," by *W. Deane;* "Myosotis collina in New England," by *E. F. Williams;* "A new wild lettuce from Massachusetts," by *B. L. Robinson;* "Notes on some fleshy fungi found near Boston," by *H. Webster;* "Matricaria discoidea in eastern Massachusetts," by *W. H. Manning;* besides shorter miscellaneous notes.

There is need for just such journals, and *Rhodora* is certain to fill its mission. The GAZETTE congratulates the editors upon the appearance of the initial number, and wishes the new venture great success. — J. M. C.

THE FIRST PART of a work on the physiology of plant organization has recently been published by Professor Dr. G. Berthold,[6] of the University of Göttingen. No criticism of this part is possible, since it is merely a record of the observations of the author regarding (1) the anatomy of the Scitamineae, (2) the anatomy and development of certain Compositæ, Umbelliferæ, and Araliaceæ; (3) the annual shoots of *Acer Pseudoplatanus;* (4) the development of some roots and axes of Pandanaceæ and palms; (5) the structure and development of leaves and stems; (6) the red coloration of leaves and stems; (7) the dying of leaves and stems.

The discussion of the observations is promised in the second part which is to appear very soon. That may be expected to show reason for the publication of what, unexplained, seem like trivial details, proper enough in a notebook, but unusual in print. The record shows an enormous amount of work, for which we are ready to express gratitude as soon as we know what it means.—C. R. B.

NOTES FOR STUDENTS.

SOME USEFUL physiological data regarding the rate of growth, flowering, nutrition, and transpiration of *Nelumbo nucifera* Gærtn. are recorded (in English) by Mr. K. Miyabe in Tokyo Botanical Magazine **12**: 85–101, 112–117. 1898.

AT A MEETING of the botanical section of the Russian Society of Naturalists at Kiew, August 1898, Professor S. Nawaschin spoke upon his new observations on fertilization in Fritillaria and Lilium. He has found true cellulose membranes on all three cells of the sexual apparatus, which were resorbed before the entrance of the sperm nucleus into the embryo sac. Both sperm cells, he asserts, enter the embryo sac, one of them penetrating the egg, while the other copulates with the nearer polar nucleus! The latter then copulates with the other polar nucleus. The brief abstract (Bot. Cent. **77**: 62. 1899) does not give further details and Nawaschin's interpretation of what

[6] BERTHOLD, G.—Untersuchungen zur Physiologie der pflanzliche Organization. Erster Teil. 8vo., pp. iv + 242, *pl. 1.* Leipzig: Wilhelm Engelmann. *M* 6.

seems most extraordinary and unlikely action of the second sperm will be awaited with interest.— Since the foregoing was in type, a preliminary paper has been published by Nawaschin[7] in which few other important facts are added. The copulation with the polar nucleus is considered as a sexual act, so that "we have to do here with a sort of polyembryony which issues in the formation of a pair of unequally developed twins, of which one develops into a segmented plant, while the other remains thallus-like and is finally consumed by the former."—C. R. B.

MR. CHARLES E. BEECHER has recently discussed[8] the origin and significance of spines, both in animals and plants. He endeavored to arrive at general conclusions relating to the origin and significance of spinosity. The main part of the paper is devoted to conclusions derived from the study of both living and fossil animals. The observations made on plants are somewhat superficial; the same general conclusions, however, are obtained in both plants and animals. These are that spines, whether prickles, thorns, or horns, represent "a stage of evolution, a degree of differentiation in the organism, a ratio of its adaptability to the environment, a result of selective forces, and a measure of vital power."

After some preliminary discussion on the law of variation, the growth and kinds of spines, the ontogeny of the spinose individual, and the phylogeny of spinose forms, the author classifies the causes of spines under eleven categories. With a few unimportant exceptions the spines of plants are referable to only two of these. The first is the "restraint of environment causing suppression of structures." In desert or arid regions leaves and branches may be suppressed to form spines. A secondary influence may determine the abundance of spinose plants in a region. Herbivorous animals destroy the unarmed species, and an old pasture may thus have the prevailing flora offensive to grazing animals. This does not produce spines, but merely drives out all species except those the animal cannot eat; hence the spines are not formed for protection, but merely assume that office as a result of selection.

The other category is "intrinsic suppression of structures and functions." This includes those prickles of brambles and climbing plants that are not produced by suppression of stipules, leaves, etc. The cause of these cortical eruptions, the author admits, is not clear, but he seems to favor the idea advanced by Bailey that they are connected with the general suppression of the plant body, and that they represent abortive attempts on the part of the plant to recover normal proportions. Prickles may often serve for protection and enable the plant to cling to a support, but this is not the initial cause.

Under categories of interpretation the author offers two generalizations,

[7] Bull. Acad. Imp. Sci. St. Pétersb. **9**: 377–382. 1898.

[8] Am. Jour. Sci. IV. **6**: 1–20, 125–136, 249–268, 329–359. 1898.

First, spinosity is a limit to variation. It is shown by the individual and the racial development that organs of various kinds are changed to spines, but spines are never changed to other organs.

Second, spinosity is the paracme of vitality. Spiny plants are "always given to die back," "often prune themselves." Spines are more or less dead structures with special physiological function. The internal or physiological changes take place in the early life of the group, while the external differentiations come about at a later period, and in this spinosity is the limit. "Spines then indicate a fixity of physiological characters together with the consequent inability of the organisms to change due to decreasing vitality." —H. N. WHITFORD.

MR. BERNHARD JACOBI (with the assistance of Professor Dr. Stahl of Jena) has prepared a summary of recent researches on proteid formation in green plants. From the *Biologisches Centralblatt* **18**: 602. 1898, we translate:

"The present state of our knowledge concerning the place and conditions for the formation of proteids in green plants . . . . is as follows:

"The special center for the synthesis of proteids is the foliage leaf.

"In the cells participating directly in proteid formation this process (under otherwise normal conditions of vegetation) may be begun in darkness, since carbohydrates enter into reaction with nitric acid, ammonia or amides to this end. But how far the process mentioned progresses depends on the amount of available carbohydrates.

"If the latter are present in abundance the formation of proteids will take place. If, on the contrary, only small amounts of carbohydrates are available, the process ceases in darkness with the formation of amides. Therefore when an adequate augmentation of the carbohydrates is provided for proteid can be produced.

"The supplying of these carbohydrates may be accomplished either artificially or naturally. In the first case the synthesis of proteids may be accomplished in darkness. By the natural method the carbohydrates could only be augmented to an adequate amount by providing, through the access of light, the conditions for assimilation of carbonic acid. In this case the light cooperates indirectly in the synthesis of proteids, because it provides the carbohydrate by the process of assimilation.

"The special source of energy is furnished by the carbohydrates themselves. However, in many cases light also appears to play a part as a source of energy. Godlewski found that, even in air free of carbonic acid, illuminated seedlings were able to form proteids from nitrates and sugar. And Detmer thinks that in this case light 'has a special importance as a source of energy' because only small amounts of carbohydrates were available." —C. R. B.

A RECENT PAPER by Dr. B. M. Davis[9] is of more than usual interest, as it contains the first description of the process of nuclear division in one of the Rhodophyceæ. The studies were carried on at Naples and at Bonn, and the tetraspore mother-cell of Corallina, one of the lime-encrusted red algæ, was selected. The nuclear figure in metakinesis is especially interesting because of the remarkable differentiation of the kinoplasm into two beautiful centrosphere-like bodies at the poles of the spindle. The centrospheres are very large homogeneous bodies without centrosomes. They arise from accumulations of kinoplasm at the opposite ends of elongated nuclei entering prophase conditions. The spindle fibers develop from these regions of differentiated protoplasm, finally appearing as extensions from the outer surface of the centrospheres. The chromatin is scattered in a very finely divided condition through the nuclear plasm, which is homogeneous in structure and lacks the usual linin network. After the division at the nuclear plate the two sets of split chromosomes are drawn up to the centrospheres, finally lying against their surfaces. Here the chromosomes of each set gradually fuse together into one larger chromatin body. The outline of each centrosphere meanwhile becomes ill-defined, and the structure loses its distinctness as a differentiated region of protoplasm, changing into an irregular dense mass, into the midst of which is drawn the chromatin body. A nuclear membrane then appears around and at a little distance from the chromatin body. The daughter nuclei thus have at first only the large chromatin body. Later the nucleolus appears, at first smaller than the chromatin body but soon growing larger. The chromatin body begins to fragment, which process finally reduces that material to the form of minute granules inside the nucleus and around the single large nucleolus. The centrosphere completely disappears as a differentiated region of the protoplasm, leaving no trace of its former presence. It seems to be the morphological expression of certain activities of the protoplasm concerned with nuclear division. There is no evidence that it is a permanent organ of the cell.— J. M. C.

[9] Kerntheilung in der Tetrasporenmutterzelle bei *Corallina officinale* L. var. *mediterranea*. Ber. d. deut. botan. Gesell. **16**: 266. 1898.

NEWS.

MR. J. G. BAKER retired as Curator of the Kew Herbarium on January 12, and was succeeded by Mr. W. B. Hemsley.

THE REMOVAL of Dr. Carl von Tubeuf from Munich to Berlin has caused the suspension of the *Forstlich-naturwissenschaftliche Zeitschrift*, of which he was editor.

DR. F. W. C. ARESCHOUG, professor of botany in the University of Lund, has retired, and Assistant Professor S. Berggren has been promoted to the place thus vacated.

DR. W. C. STURGIS has leave of absence from the Connecticut Experiment Station, and is working in the laboratory of Professor H. Marshall Ward, at Cambridge, England.

ON DECEMBER 16, 1898, Dr. Karl Müller, of Halle, the well-known bryologist and editor of *Die Natur*, celebrated his eightieth birthday. The cable brings news of his death on February ninth.

IN A BULLETIN of the Purdue University Experiment Station Dr. J. C. Arthur calls attention to the possibility of developing a beautiful bedding plant from *Cerastium arvense oblongifolium*, which, even in its wild state, is very attractive.

IN RECOGNITION of services rendered to the colonial governments as Director of the Royal Gardens at Kew, the Queen has conferred upon Mr. W. T. Thiselton Dyer the Knight Commandership of the Order of St. Michael and St. George (K. C. M. G.).

MR. CHARLES A. KEFFER, of the Division of Forestry, United States Department of Agriculture, has been appointed Horticulturist in the Agricultural College of New Mexico at Mesilla Park. He will leave Washington for his new work about the last of February.

FATHER J. H. WIBBE died at his residence in Schenectady, N. Y., January 7, 1899, at the age of 60. He was well known to the older botanists as an enthusiastic collector and student of the local flora; and to those who enjoyed his personal acquaintance as a most genial friend.

THE OHIO STATE ACADEMY OF SCIENCE held its eighth annual meeting December 29 and 30 at the State University. Botanical papers were read by John H. Schaffner, A. D. Selby, Lumina C. Riddle, H. C. Beardslee, E. L. Fullmer, Edo Claassen, W. A. Kellerman, G. M. Holferty, and E. L. Moseley.

THE PHYSICS GARDEN of the Society of Apothecaries, Chelsea, London, founded by Sir Hans Sloane in 1722, which has of late years been much neglected, is to be rejuvenated and suitably maintained. New offices, lecture rooms, and a physiological laboratory are to be built, a curator and head gardener appointed, and suitable lectureships established.

DR. ROLAND THAXTER, during his visit abroad last spring and summer, obtained specimens of Laboulbeniaceæ at Paris, London, and Oxford, representing material of world wide distribution. These collections will probably double the size of the family. On account of Mr. Thaxter's serious illness, from which he has happily recovered, work upon them has been delayed.

MR. GILBERT H. HICKS, of the Department of Agriculture died suddenly at his home in Washington December 7, 1898. He was First Assistant Botanist and Seed Expert, and was also editor of the *Asa Gray Bulletin*. He was a native of Michigan, and received his government appointment in 1894. Mr. A. J. Pieters, heretofore associated with Mr. Hicks, has succeeded him in charge of the pure seed investigations.

PROFESSOR D. T. MACDOUGAL of the Botanical Department of the University of Minnesota has been appointed Director of the Laboratories of the New York Botanical Garden. He will take up his new duties July 1, at which time the new museum and laboratory building of the Garden will be ready for occupancy. The laboratories in question will be devoted entirely to research work. No students will be received until an adequate laboratory equipment has been secured and put in place, a matter which will occupy the director's attention for a few months. This transfer leaves a vacancy in the assistant professorship of botany at the University of Minnesota. It will probably be filled at the April meeting of the Board of Regents.

THE EXTENSIVE collection of Compositæ of the late Dr. F. W. Klatt of Hamburg, the well-known specialist in this order, has been purchased by the Gray Herbarium of Harvard University. The collection is estimated to contain about 11,000 specimens, together with very numerous and skillfully executed drawings of types. The indefatigable character of Dr. Klatt's work is recognized by all who have been interested in tropical Compositæ. Indeed there are scarcely any medium sized or large genera of the order which have not been enriched by his specific characterizations. Especially numerous are his species of Vernonia, Eupatorium, Verbesina, and Senecio. Of Dr. Klatt's species (except the Costa Rican plants of Pittier) the representation in America has hitherto been very incomplete. The Klatt Herbarium, however, contains not only the Klatt types but numerous authentic specimens of other rare species, and from a conservative estimate, based upon a partial count, it is believed that the collection includes no less than 60 genera and 1500 species not hitherto represented in the Gray Herbarium or, for the most

part, in American herbaria at all. Before the accession of the Klatt collection, the Compositæ of the Gray Herbarium were estimated at about 35,000 mounted sheets, many of which hold two to five specimens.

THE WASHINGTON BOTANICAL CLUB was organized by a gathering of botanists held at the residence of one of its members November 11, 1898. The limit of membership was fixed at twenty, and it was determined that the meetings, for the present at least, should be of a distinctly social and informal nature, with free opportunity for discussion and the general interchange of ideas. At a subsequent meeting, held December 14, the organization was perfected by the election of Professor Edward L. Greene as President, and Mr. Charles L. Pollard as Secretary. The Club is to hold monthly sessions, devoting itself chiefly to systematic and ecological work, the field of plant physiology and pathology being covered by the already existing Botanical Seminar.

At the December meeting the following resolutions, commemorative of the late Gilbert H. Hicks, were unanimously adopted:

"It is with extreme sorrow and heartfelt regret that we learn of the death of our friend and colleague, Mr. Gilbert H. Hicks. To all of us he was known intimately as an earnest co-worker in the field of science, and a genial member of our social organizations. His energy, earnestness, and conscientiousness in scientific work commanded our approval, and secured recognition for him in all circles as an able investigator. He had already done much to advance knowledge in his chosen line of work, and we feel that the cause of science has lost greatly by his untimely death.

"Much of his work, though of a high scientific character, had been so directed as to yield results of the greatest practical value in the production of food crops, and was intended to lighten in some degree the burden of struggling humanity. As a botanist his keen appreciation of practical problems and his extensive knowledge of plant life well fitted him for this work for the people, and not only science has lost by his death, but all tillers of the soil, those who plow, sow, and reap, have lost a true friend and counselor.

"Yet to us, his daily associates, the loss is greatest. We shall miss his cheery greetings, his companionship, his counsel. It is thus with feelings of deepest sorrow and regret that we have learned that he has been taken from us while yet in the prime and vigor of early manhood. To his sorrowing family we desire to express our heartfelt sympathy and condolence. We realize how inexpressibly great the loss has been to them, and we mourn with them.

"Resolved that a copy of the above resolutions be sent to the family of the deceased, and to the leading botanical magazines in this country."—CHARLES LOUIS POLLARD, *Secretary*.